

IN THE UNITED STATES DISTRICT COURT  
FOR THE DISTRICT OF DELAWARE

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IN RE: REMBRANDT TECHNOLOGIES, LP  
PATENT LITIGATION

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) MDL Docket No. 07-md-1848 (GMS)  
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MOTOROLA, INC., CISCO SYSTEMS, INC.,  
SCIENTIFIC-ATLANTIA, INC., ARRIS GROUP,  
INC., THOMSON, INC., AMBIT  
MICROSYSTEMS, INC., and NETGEAR, INC.,

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)  
) Civil Action No. 07-752-GMS  
)  
)

Plaintiffs,

) JURY TRIAL DEMANDED  
)  
)

v.

REMBRANDT TECHNOLOGIES, LP, and  
REMBRANDT TECHNOLOGIES, LLC d/b/a  
REMSTREAM,

Defendants.

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REMBRANDT TECHNOLOGIES, LP, and  
REMBRANDT TECHNOLOGIES, LLC, d/b/a  
REMSTREAM,

Counter-Plaintiffs,

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)  
)  
) Civil Action No. 07-752-GMS  
)  
)

v.

) JURY TRIAL DEMANDED  
)  
)

MOTOROLA, INC., CISCO SYSTEMS, INC.,  
SCIENTIFIC-ATLANTIA, INC., ARRIS GROUP,  
INC., THOMSON, INC., AMBIT  
MICROSYSTEMS, INC., NETGEAR, INC.,  
TIME WARNER CABLE, INC., TIME  
WARNER CABLE LLC, TIME WARNER NY  
CABLE LLC, TIME WARNER  
ENTERTAINMENT-ADVANCE/NEWHOUSE  
PARTNERSHIP, TIME WARNER  
ENTERTAINMENT COMPANY, LP,  
COMCAST CORPORATION, COMCAST  
CABLE COMMUNICATIONS, LLC, CHARTER  
COMMUNICATIONS OPERATING, LLC,

COXCOM, INC., CSC HOLDINGS, INC., )  
 CABLEVISION SYSTEMS CORPORATION, )  
 ADELPHIA COMMUNICATIONS )  
 CORPORATION, CENTURY-TCI )  
 CALIFORNIA COMMUNICATIONS, LP, )  
 CENTRUY-TCI HOLDINGS, LLC, )  
 COMCAST OF FLORIDA/PENNSYLVANIA, )  
 L.P. (f/k/a PARNASSOS, LP), COMCAST OF )  
 PENNSYLVANIA II, L.P. (f/k/a CENTURY-TCI )  
 CALIFORNIA, L.P.), PARNASSOS )  
 COMMUNICATIONS, LP, ADELPHIA )  
 CONSOLIDATION, LLC, PARNASSOS )  
 HOLDINGS, LLC, WESTERN NY )  
 CABLEVISION, LP, SHARP CORPORATION, )  
 and SHARP ELECTRONICS CORPORATION, )  
 )  
 Counter-Defendants. )

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**ANSWER OF REMBRANDT TECHNOLOGIES, LP AND REMBRANDT  
 TECHNOLOGIES, LLC D/B/A REMSTREAM TO AMENDED COMPLAINT OF  
 MOTOROLA, INC., CISCO SYSTEMS, INC., SCIENTIFIC-ATLANTIA, INC.,  
 ARRIS GROUP, INC., THOMSON, INC., AMBIT MICROSYSTEMS, INC.  
 AND NETGEAR, INC.  
 AND  
 COUNTERCLAIMS OF REMBRANDT TECHNOLOGIES, LP AND REMBRANDT  
TECHNOLOGIES, LLC D/B/A REMSTREAM**

Rembrandt Technologies, LP (“Rembrandt”) and Rembrandt Technologies, LLC d/b/a Remstream (“Remstream”) respectfully submit this Answer to the Amended Complaint for Declaratory Judgment of Patent Invalidity, Noninfringement, and Unenforceability filed by Motorola, Inc. (“Motorola”), Cisco Systems, Inc. (“Cisco”), Scientific-Atlanta, Inc. (“Scientific-Atlanta”), ARRIS Group, Inc. (“ARRIS”), Thomson, Inc. (“Thomson”), Ambit Microsystems, Inc. (“Ambit”) and NETGEAR, Inc. (“NETGEAR”) (collectively “Plaintiffs”), and Rembrandt and Remstream respectfully submit their Counterclaims against Plaintiffs/Counter-Defendants and additional counter-defendants Time Warner Cable, Inc., Time Warner Cable LLC, Time

Warner NY Cable LLC, Time Warner Entertainment Company, LP, Time Warner Entertainment-Advance/Newhouse Partnership, Comcast Corporation, Comcast Cable Communications, LLC, Comcast Cable Communications Holdings, Inc., Charter Communications, Inc., Charter Communications Operating, LLC, CSC Holdings, Inc., CoxCom, Inc., Cablevision Systems Corporation, Adelphia Communications Corporation, Century-TCI California Communications, LP, Century-TCI Holdings, LLC, Comcast of Florida/Pennsylvania, L.P. (f/k/a Parnassos, LP), Comcast of Pennsylvania II, L.P. (f/k/a Century-TCI California, L.P.), Parnassos Communications, LP, Adelphia Consolidation, LLC, Parnassos Holdings, LLC, Western NY Cablevision, LP (collectively “Multiple System Operator Counter-Defendants” or “MSO Counter-Defendants”) and Sharp Corporation and Sharp Electronics Corporation (collectively “Sharp”) and state as follows:

**REMBRANDT TECHNOLOGIES, LP’S AND REMBRANDT  
TECHNOLOGIES LLC’S ANSWER TO THE AMENDED COMPLAINT**

Plaintiffs have inserted unnumbered paragraphs purporting to summarize the allegations of their Amended Complaint. To the extent a response is required, the responses herein to the relevant numbered paragraphs are incorporated.

**PARTIES**

1. Plaintiff Ambit is a California corporation with its principal place of business at 9570 La Costa Lane, Lone Tree, CO 80124.

Answer: Upon information and belief, Rembrandt and Remstream admit that Ambit MicroSystems, Inc. (“Ambit”) is a California corporation with its principal place of business at 9570 La Costa Lane, Lone Tree, CO 80124.

2. Plaintiff ARRIS is a Delaware corporation with its principal place of business at 3871 Lakefield Drive, Suwanee, GA, 30024.

Answer: Upon information and belief, Rembrandt and Remstream admit that ARRIS Group, Inc. ("ARRIS") is a Delaware corporation with its principal place of business at 3871 Lakefield Drive, Suwanee, GA 30024.

3. Plaintiff Cisco is a California corporation with its principal place of business at 170 West Tasman Drive, San Jose, CA 95134.

Answer: Upon information and belief, Rembrandt and Remstream admit that Cisco Systems, Inc. ("Cisco") is a California corporation with its principal place of business at 170 West Tasman Drive, San Jose, CA 95134.

4. Plaintiff Motorola is a Delaware corporation with its principal place of business at 1303 E. Algonquin Road, Schaumburg, IL 60196.

Answer: Upon information and belief, Rembrandt and Remstream admit that Motorola, Inc. ("Motorola") is a Delaware corporation with its principal place of business at 1303 E. Algonquin Road, Schaumburg, IL 60196.

5. Plaintiff NETGEAR is a Delaware corporation with its principal place of business at 4500 Great America Parkway, Santa Clara, CA 95054.

Answer: Upon information and belief, Rembrandt and Remstream admit that NETGEAR, Inc. ("NETGEAR") is a Delaware corporation with its principal place of business at 4500 Great America Parkway, Santa Clara, CA 95054.

6. Plaintiff Scientific-Atlanta is a wholly owned subsidiary of Plaintiff Cisco and is a Georgia corporation with its principal place of business at 5030 Sugarloaf Parkway, Lawrenceville, GA 30044-2869.

Answer: Upon information and belief, Rembrandt and Remstream admit that Scientific-Atlanta, Inc. ("Scientific-Atlanta") is a wholly owned subsidiary of Cisco and is a Georgia corporation with its principal place of business at 5030 Sugarloaf Parkway, Lawrenceville, GA 30044-2869.

7. Plaintiff Thomson is a Delaware corporation with its principal place of business at 101 W. 103rd Street, INH 3340, Indianapolis, IN 46290.

Answer: Upon information and belief, Rembrandt and Remstream admit that Thomson, Inc. ("Thomson") is a Delaware corporation with its principal place of business at 101 W. 103rd Street, INH 3340, Indianapolis, IN 46290.

8. On information and belief, defendant Rembrandt is a limited partnership organized and existing under the laws of New Jersey, with a principal place of business at 401 City Avenue, Suite 528, Bala Cynwyd, PA 19004. Rembrandt asserts that its business is enforcing and licensing patents. In carrying out its business of patent enforcement, Rembrandt has sued Cablevision Systems Corporation and CSC Holdings Inc., in C.A. No. 06-635-GMS. In that action, Rembrandt has asserted that "DOCSIS is a specification that describes the operational parameters of equipment that is used for cable networks. Rembrandt alleges that DOCSIS-compliant equipment infringes the '631, '858, '819, and '903 patents." Rembrandt purports to have obtained the patents at-issue in this action by purchasing them from Paradyne Corp., a Delaware corporation, and Zhone Communications. Rembrandt has also filed patent infringement law suits on another patent in this forum, suing ABC Inc., CBS Corporation, NBC Universal, Fox Entertainment Group Inc. and Fox Broadcasting Company. Those actions can be found as C.A. No. 06-727-GMS, C.A. No. 06-729-GMS, C.A. No. 06-730-GMS and C.A. No. 06-731-GMS. Rembrandt has also caused to be formed in Delaware a number of limited liability corporations, limited partnerships, limited liability limited partnerships and/or corporations. On information and belief, Rembrandt has caused those entities to be formed to assist with its business of patent enforcement and licensing.

Answer: Admitted that Rembrandt is a limited partnership organized under the laws of the State of New Jersey. Denied that Rembrandt has its principal place of business at 401 City Avenue, Suite 528, Bala Cynwyd, PA 19004; Rembrandt's principal place of business is Suite 900 at the aforementioned address. Admitted that part of Rembrandt's business is enforcing and licensing patents. Admitted that Rembrandt instituted patent infringement actions against

Cablevision Systems Incorporated and CSC Holdings, Inc. (C.A. No. 06-635), and against ABC, Inc. (C.A. No. 06-730), CBS Corporation (C.A. No. 06-7272), NBC Universal, Inc. (C.A. No. 06-729), and Fox Entertainment Group Inc. and Fox Broadcasting Company (C.A. No. 06-731) in the District of Delaware. The allegations in those complaints are in writing and speak for themselves. Admitted that Rembrandt obtained the patents at issue in this action from Paradyne Corp. and Zhone Communications, and that Rembrandt formed in Delaware a number of LLCs. The remaining allegations in paragraph 8 are denied.

9. On information and belief, defendant Rembrandt Technologies, LLC, a Delaware LLC, is wholly owned by Rembrandt and does business as "Remstream." Remstream has its headquarters at 401 City Avenue, Suite 900, Bala Cynwyd, PA 19004.

Answer: Admitted that Rembrandt Technologies, LLC is a Delaware Limited Liability Company that is wholly owned by Rembrandt Technologies, LP, and that Rembrandt Technologies, LLC also does business as "Remstream" and has its headquarters at 401 City Avenue, Suite 900, Bala Cynwyd, PA 19004.

#### **NATURE OF THE ACTION**

10. In this action, Plaintiffs seek a declaratory judgment of patent noninfringement and invalidity of eight United States Patents pursuant to the Declaratory Judgment Act, 28 U.S.C. §§ 2201-02, and the Patent Laws of the United States, 35 U.S.C. § 100 *et seq.*, damages, and such other relief as the Court deems just and proper.

Answer: Rembrandt and Remstream admit that Plaintiffs purport to bring a declaratory judgment of patent noninfringement and invalidity of eight United States patents under the Declaratory Judgment Act, 28 U.S.C. §§ 2201-02, and the patent laws of the United States, 35 U.S.C. § 100 *et seq.*, but denies that Plaintiffs are entitled to their requested relief.

### **JURISDICTION AND VENUE**

11. This Court has jurisdiction over this action under, and without limitation, 28 U.S.C. §§ 1331, 1337, 1338(a), 1367, 2201, and 2202, and the Patent Laws of the United States, 35 U.S.C. § 1 *et seq.*

Answer: Rembrandt and Remstream do not contest this Court's jurisdiction over the subject matter of at least some of the claims asserted in this action under 28 U.S.C. §§ 1331 and 1338(a). Rembrandt and Remstream admit that Plaintiffs purport to bring their claims for a declaratory judgment pursuant to 28 U.S.C. §§ 2201-2202, but denies the viability of Plaintiffs' request for declaratory judgment.

12. Venue is proper in this judicial district under 28 U.S.C. §§ 1391 and 1400(b).

Answer: Rembrandt and Remstream do not contest that venue is proper in this judicial district under 28 U.S.C. §§ 1391 and 1400(b), but denies that Plaintiffs are entitled to their requested relief.

### **RELATED ACTIONS**

13. Pursuant to D. Del. LR 3.1(b), Plaintiffs state that this declaratory judgment action is related to the following actions (the "Related Actions"):

- *Rembrandt Technologies, LP v. Cablevision et al.*, C.A. No. 06-635-GMS;
- *Coxcom v. Rembrandt Technologies, LP*, C.A. No. 06-721-GMS;
- *Rembrandt Technologies, LP v. Adelphia Comm'n Corp., et al.*, C.A. No. 07-396-GMS;
- *Rembrandt Technologies, LP v. Adelphia Comm'n Corp., et al.*, C.A. No. 07-397-GMS;
- *Rembrandt Technologies, LP v. Comcast Corp. et al.*, C.A. No. 07-398-GMS;
- *Rembrandt Technologies, LP v. Charter Comm'n, Inc., et al.*, C.A. No. 07-400-GMS;
- *Rembrandt Technologies, LP v. Time Warner Cable, et al.*, C.A. No. 07-401-GMS;
- *Rembrandt Technologies, LB v. Time Warner Cable, et al.*, C.A. No. 07-402-GMS;
- *Rembrandt Technologies, LB v. Comcast Corp. et al.*, C.A. No. 07-403-GMS;



- *Rembrandt Technologies, LP v. Charter Comm'n, Inc., et al.*, C.A. No. 07-404-GMS;
- *In re Rembrandt Technologies, LP Patent Litigation*, C.A. No. 07-1848-GMS.

Answer: Rembrandt and Remstream do not contest that the cases listed in paragraph 13 are "Related Actions" under D. Del. LR 3.1(b).

### **THE PATENTS**

14. U.S. Patent No. 4,937,819 ("the '819 patent") entitled "Time Orthogonal Multiple Virtual DCE for Use in Analog and Digital Networks" reports that it was filed on September 26, 1988 and issued on June 26, 1990. The inventor named on the '819 patent is Joseph B. King. A copy of the '819 patent is attached hereto as Exhibit A. As alleged herein, Plaintiffs deny that the patent duly and legally issued.

Answer: Admitted, except it is averred that the '819 patent was duly and legally issued.

15. U.S. Patent No. 5,008,903 ("the '903 patent") entitled "Adaptive Transmit Pre-Emphasis for Digital Modem Computed from Noise Spectrum" reports that it was filed on May 25, 1989 and issued on April 16, 1991. The inventors named on the '903 patent are William L. Betts and James J. DesRosiers. A copy of the '903 patent is attached hereto as Exhibit B. As alleged herein, Plaintiffs deny that the patent duly and legally issued.

Answer: Admitted, except it is averred that the '903 patent was duly and legally issued.

16. U.S. Patent No. 5,710,761 ("the '761 patent") entitled "Error Control Negotiation Based on Modulation" reports that it was filed on May 31, 1995 and issued on January 20, 1998. The inventor named on the '761 patent is Robert Earl Scott. A copy of the '761 patent is attached hereto as Exhibit C. As alleged herein, Plaintiffs deny that the patent duly and legally issued.

Answer: Admitted, except it is averred that the '761 patent was duly and legally issued.

17. U.S. Patent No. 5,719,858 ("the '858 patent") entitled "Time-Division Multiple-Access Method for Packet Transmission on Shared Synchronous Serial Buses" reports that it was filed on July 31, 1995 and issued on February 17, 1998. The inventor named on the '858 patent is Wayne T. Moore. A copy of the '858 patent is attached hereto as Exhibit D. As alleged herein, Plaintiffs deny that the patent duly and legally issued.

Answer: Admitted, except it is averred that the '858 patent was duly and legally issued.



18. U.S. Patent No. 5,778,234 (“the ‘234 patent”) entitled “Method for Downloading Programs” reports that it was filed on July 24, 1997 and issued on July 7, 1998. The inventors named on the ‘234 patent are Gideon Hecht, Kurt Ervin Holmquist, and Donald C. Snoll. A copy of the ‘234 patent is attached hereto as Exhibit E. As alleged herein, Plaintiffs deny that the patent duly and legally issued.

Answer: Admitted, except it is averred that the ‘234 patent was duly and legally issued.

19. U.S. Patent No. 5,852,631 (“the ‘631 patent”) entitled “System and Method for Establishing Link Layer Parameters Based on Physical Layer Modulation” reports that it was filed on January 8, 1997 and issued on December 22, 1998. The inventor named on the ‘631 patent is Robert Earl Scott. A copy of the ‘631 patent is attached hereto as Exhibit F. As alleged herein, Plaintiffs deny that the patent duly and legally issued.

Answer: Admitted, except it is averred that the ‘631 patent was duly and legally issued.

20. U.S. Patent No. 6,131,159 (“the ‘159 patent”) entitled “System for Downloading Programs” reports that it was filed on May 8, 1992 and issued on October 10, 2000. The inventors named on the ‘159 patent are Gideon Hecht, Kurt Ervin Holmquist, and Donald C. Snoll. A copy of the ‘159 patent is attached as Exhibit G. As alleged herein, Plaintiffs deny that the patent duly and legally issued.

Answer: Admitted, except it is averred that the ‘159 patent was duly and legally issued.

21. U.S. Patent No. 6,950,444 (“the ‘444 patent”) entitled “System and Method for a Robust Preamble and Transmission Delimiting in a Switched-Carrier Transceiver” reports that it was filed on August 11, 2000 and issued on September 27, 2005. The inventors named on the ‘444 patent are Kurt Holmquist and Joseph Chapman. A copy of the ‘444 patent is attached as Exhibit H. As alleged herein, Plaintiffs deny that the patent duly and legally issued.

Answer: Admitted, except it is averred that the ‘444 patent was duly and legally issued.

22. Rembrandt asserts (but Plaintiffs do not admit) that Rembrandt is the owner of all rights, title, and interest in and to the ‘819, ‘903, ‘761, ‘858, ‘234, ‘631, ‘159, and ‘444 patents (collectively, the “Patents”). Rembrandt did not invent the technology in the Patents. Rembrandt also did not invent DOCSIS or contribute to the development of DOCSIS. Rembrandt purports to have obtained the Patents through an agreement with Paradyne Corporation. Paradyne Corporation did not invent DOCSIS. Paradyne Corporation did not participate in the creation of DOCSIS. Paradyne did not sell cable modems or cable modem termination systems. Rembrandt has contended in discovery responses in one or more of the MSO actions that Paradyne sold products in the United States that Rembrandt alleges to practice the Patents. Rembrandt has also admitted that Paradyne products sold in the United States were

not marked with the Patents. Rembrandt is presently aware that Paradyne sold products in the United States that were not marked with the Patents and Rembrandt believes that those products practiced claims of the Patents.

Answer: Admitted that Rembrandt purchased some, but not all, of the patents from Paradyne Corporation, and that with respect to those patents, Rembrandt purchased all of Paradyne's rights to those patents; that Rembrandt is the owner of the '819, '903, '761, '858, '234, '631, '158, and '444 patents; that Rembrandt is the owner of all the right, title, and interest in and to the '819, '903, '858, and '631 patents, and Rembrandt, subject to the rights granted to Remstream, is also the owner of all right, title, and interest in and to the '761, '234, '159, and '444 patents; that it did not invent the technology in the patents; and that neither it nor Paradyne participated in the development of DOCSIS. Rembrandt and Remstream deny that DOCSIS is an invention. Rembrandt and Remstream believe that the allegation that Paradyne did not sell cable modems or cable modem termination systems is correct. With respect to the allegations regarding what Rembrandt "has contended" or "has also admitted," such statements are in writing and speak for themselves. Rembrandt and Remstream believe that it is accurate that Paradyne sold products in the United States which practiced some of the claims of some of the patents, but Rembrandt and Remstream are without knowledge or information sufficient to admit or deny whether any or all of those products were marked with those patents. Except as expressly admitted, Rembrandt and Remstream deny the remaining allegations in paragraph 22.

## COUNT I

### **(Declaratory Judgment Action for a Declaration of Noninfringement and Invalidity of U.S. Patent No. 4,937,819)**

23. Paragraphs 1 through 22 are incorporated by reference as if stated fully herein.

Answer: Rembrandt and Remstream incorporate by reference their responses to paragraphs 1-22 as though fully set forth herein.

24. Rembrandt has accused Cablevision Systems Corporation, Charter Communications Operating, LLC, Charter Communications, Inc., Comcast Cable Communications, LLC, Comcast Corporation, Comcast of Plano, LP, Coxcom, Inc., CSC Holdings, Inc., Time Warner Cable Inc., Time Warner Cable LLC, Time Warner Entertainment-Advance/Newhouse Partnership, Time Warner Entertainment Company, L.P. and Time Warner New York Cable LLC of infringing the '819 patent because of the operational parameters of the cable equipment that they purchase for their cable systems. Specifically, Rembrandt has alleged that DOCSIS is a specification that describes operational parameters of equipment that is used for cable networks. Rembrandt further asserts that DOCSIS-compliant cable modem ("CM") and cable modem termination system ("CMTS") equipment allegedly infringe the '819 patent. Plaintiffs manufacture and sell accused CM and/or CMTS equipment, and each of Plaintiffs has supplied accused CM and/or CMTS equipment to one or more of the cable MSOs that Rembrandt has accused of infringement.

Answer: Rembrandt and Remstream admit that Rembrandt accused the entities listed in paragraph 24 of infringing the '819 patent. Rembrandt and Remstream admit that DOCSIS is a specification that describes operational parameters of equipment used for cable networks. Rembrandt and Remstream also admit that DOCSIS compliant cable modems and cable termination system ("CMTS") equipment, when used in conjunction with a cable company's cable network, infringe the '819 patent. Rembrandt and Remstream deny the remaining allegations of paragraph 24, except that Rembrandt and Remstream, after reasonable investigation, lack sufficient knowledge or information to admit or deny the truth of the allegations of the last sentence in paragraph 24.

25. An actual and justiciable controversy exists between Plaintiffs and Rembrandt regarding the infringement and validity of the '819 patent.

Answer: Admitted.

26. Plaintiffs have not infringed (directly or indirectly) any valid, enforceable claim of the '819 patent, either literally or under the doctrine of equivalents.

Answer: Denied.

27. The '819 patent is invalid because of its failure to meet the conditions of patentability and/or otherwise comply with the requirements of 35 U.S.C. §§ 101, 102, 103, and/or 112.

Answer: Denied.

28. A judicial declaration of noninfringement and invalidity is necessary and appropriate in order to resolve this controversy.

Answer: Denied.

**COUNT II**  
**(Declaratory Judgment Action for a Declaration**  
**of Noninfringement and Invalidity of U.S. Patent No. 5,008,903)**

29. Paragraphs 1 through 22 are incorporated by reference as if stated fully herein.

Answer: Rembrandt and Remstream incorporate by reference their responses to paragraphs 1-28 as though fully set forth herein.

30. Rembrandt has accused Cablevision Systems Corporation, Charter Communications Operating, LLC, Charter Communications, Inc., Comcast Cable Communications, LLC, Comcast Corporation, Comcast of Piano, LP, Coxcom, Inc., CSC Holdings, Inc., Time Warner Cable Inc., Time Warner Cable LLC, Time Warner Entertainment-Advance/Newhouse Partnership, Time Warner Entertainment Company, L.P. and Time Warner New York Cable LLC of infringing the '903 patent because of the operational parameters of the cable equipment that they purchase for their cable systems. Specifically, Rembrandt has alleged that DOCSIS is a specification that describes operational parameters of equipment that is used for cable networks. Rembrandt further asserts that DOCSIS-compliant cable modem ("CM") and cable modem termination system ("CMTS") equipment allegedly infringe the '903 patent. Plaintiffs manufacture and sell accused CM and/or CMTS equipment, and each of Plaintiffs has supplied accused CM and/or CMTS equipment to one or more of the cable MSOs that Rembrandt has accused of infringement.

Answer: Rembrandt and Remstream admit that Rembrandt accused the entities listed in paragraph 30 of infringing the '903 patent. Rembrandt and Remstream admit that DOCSIS is a specification that describes operational parameters of equipment used for cable networks. Rembrandt and Remstream also admit that DOCSIS compliant cable modems and cable

termination system ("CMTS") equipment, when used in conjunction with a cable company's cable network, infringe the '903 patent. Rembrandt and Remstream deny the remaining allegations of paragraph 30, except that Rembrandt and Remstream, after reasonable investigation, lack sufficient knowledge or information to admit or deny the truth of the allegations of the last sentence in paragraph 30.

31. An actual and justiciable controversy exists between Plaintiffs and Rembrandt regarding the infringement and validity of the '903 patent.

Answer: Admitted.

32. Plaintiffs have not infringed (directly or indirectly) any valid, enforceable claim of the '903 patent, either literally or under the doctrine of equivalents.

Answer: Denied.

33. The '903 patent is invalid because of its failure to meet the conditions of patentability and/or otherwise comply with the requirements of 35 U.S.C. §§ 101,102,103, and/or 112.

Answer: Denied.

34. A judicial declaration of noninfringement and invalidity is necessary and appropriate in order to resolve this controversy.

Answer: Denied.

**COUNT III**  
**(Declaratory Judgment Action for a Declaration**  
**of Noninfringement and Invalidity of U.S. Patent No. 5,710,761)**

35. Paragraphs 1 through 22 are incorporated by reference as if stated fully herein.

Answer: Rembrandt and Remstream incorporate by reference their responses to paragraphs 1-34 as thought fully set forth herein.

36. Rembrandt has accused Adelphia Communications Corporation, Century-TCJ Distribution Company, LLC, Century-TCI California, LP, Century-TCI California Communications, LP, Century-TCI Holdings, LLC, Charter Communications Operating, LLC, Charter Communications, Inc., Comcast Cable Communications, LLC, Comcast Corporation, Comcast of Plano, LP, Coxcom, Inc., Parnassos Communications, LP, Parnassos Distribution Company I, LLC, Parnassos Distribution Company II, LLC, Parnassos Holdings, LLC, Parnassos, LP, Time Warner Cable Inc., Time Warner Cable LLC, Time Warner Entertainment-Advance/Newhouse Partnership, Time Warner Entertainment Company, L.P., Time Warner New York Cable LLC and Western NY Cablevision, LP of infringing the '761 patent because of the operational parameters of the cable equipment that they purchase for their cable systems. Specifically, Rembrandt has alleged that DOCSIS is a specification that describes operational parameters of equipment that is used for cable networks. Rembrandt further asserts that DOCSIS-compliant cable modem ("CM") and cable modem termination system ("CMTS") equipment allegedly infringe the '761 patent. Plaintiffs manufacture and sell accused CM and/or CMTS equipment, and each of Plaintiffs has supplied accused CM and/or CMTS equipment to one or more of the cable MSOs that Rembrandt has accused of infringement.

Answer: Rembrandt and Remstream admit that Rembrandt accused the entities listed in paragraph 36 of infringing the '761 patent. Rembrandt and Remstream admit that DOCSIS is a specification that describes operational parameters of equipment used for cable networks. Rembrandt and Remstream also admit that DOCSIS compliant cable modems and cable termination system ("CMTS") equipment, when used in conjunction with a cable company's cable network, infringe the '761 patent. Rembrandt and Remstream deny the remaining allegations of paragraph 36, except that Rembrandt and Remstream, after reasonable investigation, lack sufficient knowledge or information to admit or deny the truth of the allegations of the last sentence in paragraph 36.

37. An actual and justiciable controversy exists between Plaintiffs and Rembrandt regarding the infringement and validity of the '761 patent.

Answer: Admitted.

38. Plaintiffs have not infringed (directly or indirectly) any valid, enforceable claim of the '761 patent, either literally or under the doctrine of equivalents.

Answer: Denied.



39. The '761 patent is invalid because of its failure to meet the conditions of patentability and/or otherwise comply with the requirements of 35 U.S.C. §§ 101, 102, 103, and/or 112.

Answer: Denied.

40. A judicial declaration of noninfringement and invalidity is necessary and appropriate in order to resolve this controversy.

Answer: Denied.

**COUNT IV**  
**(Declaratory Judgment Action for a Declaration**  
**of Noninfringement and Invalidity of U.S. Patent No. 5,719,858)**

41. Paragraphs 1 through 22 are incorporated by reference as if stated fully herein.

Answer: Rembrandt and Remstream incorporate by reference their responses to paragraphs 1-40 as though fully set forth herein.

42. Rembrandt has accused Cablevision Systems Corporation, Charter Communications Operating, LLC, Charter Communications, Inc., Comcast Cable Communications, TIC, Comcast Corporation, Comcast of Piano, LP, Coxcom, Inc., CSC Holdings, Inc., Time Warner Cable Inc., Time Warner Cable LLC, Time Warner Entertainment-Advance/Newhouse Partnership, Time Warner Entertainment Company, L.P. and Time Warner New York Cable LLC of infringing the '858 patent because of the operational parameters of the cable equipment that they purchase for their cable systems. Specifically, Rembrandt has alleged that DOCSIS is a specification that describes operational parameters of equipment that is used for cable networks. Rembrandt further asserts that DOCSIS-compliant cable modem ("CM") and cable modem termination system ("CMTS") equipment allegedly infringe the '858 patent. Plaintiffs manufacture and sell accused CM and/or CMTS equipment, and each of Plaintiffs has supplied accused CM and/or CMTS equipment to one or more of the cable MSOs that Rembrandt has accused of infringement.

Answer: Rembrandt and Remstream admit that Rembrandt accused the entities listed in paragraph 42 of infringing the '858 patent. Rembrandt and Remstream admit that DOCSIS is a specification that describes operational parameters of equipment used for cable networks. Rembrandt and Remstream also admit that DOCSIS compliant cable modems and cable



termination system ("CMTS") equipment, when used in conjunction with a cable company's cable network, infringe the '858 patent. Rembrandt and Remstream deny the remaining allegations of paragraph 42, except that Rembrandt and Remstream, after reasonable investigation, lack sufficient knowledge or information to admit or deny the truth of the allegations of the last sentence in paragraph 42.

43. An actual and justiciable controversy exists between Plaintiffs and Rembrandt regarding the infringement and validity of the '858 patent.

Answer: Admitted.

44. Plaintiffs have not infringed (directly or indirectly) any valid, enforceable claim of the '858 patent, either literally or under the doctrine of equivalents.

Answer: Denied.

45. The '858 patent is invalid because of its failure to meet the conditions of patentability and/or otherwise comply with the requirements of 35 U.S.C. §§ 101, 102, 103, and/or 112.

Answer: Denied.

46. A judicial declaration of noninfringement and invalidity is necessary and appropriate in order to resolve this controversy.

Answer: Denied.

**COUNT V**  
**(Declaratory Judgment Action for a Declaration**  
**of Noninfringement and Invalidity of U.S. Patent No. 5,778,234)**

47. Paragraphs 1 through 22 are incorporated by reference as if stated fully herein.

Answer: Rembrandt and Remstream incorporate by reference their responses to paragraphs 1-46 as though fully set forth herein.

48. Rembrandt has accused Adelphia Communications Corporation, Century-TCI Distribution Company, LLC, Century-TCI California, LP, Century-TCI California Communications, LP, Century-TCI Holdings, LLC, Charter Communications Operating, LLC, Charter Communications, Inc., Comcast Cable Communications, LLC, Comcast Corporation, Comcast of Plano, LP, Coxcom, Inc., Parnassos Communications, LP, Parnassos Distribution Company I, LLC, Parnassos Distribution Company II, LLC, Parnassos Holdings, LLC, Parnassos, LP, Time Warner Cable Inc., Time Warner Cable LLC, Time Warner Entertainment-Advance/Newhouse Partnership, Time Warner Entertainment Company, L.P., Time Warner New York Cable LLC and Western NY Cablevision, LP of infringing the '234 patent because of the operational parameters of the cable equipment that they purchase for their cable systems. Specifically, Rembrandt has alleged that DOCSIS is a specification that describes operational parameters of equipment that is used for cable networks. Rembrandt further asserts that DOCSIS-compliant cable modem ("CM") and cable modem termination system ("CMTS") equipment allegedly infringe the '234 patent. Plaintiffs manufacture and sell accused CM and/or CMTS equipment, and each of Plaintiffs has supplied accused CM and/or CMTS equipment to one or more of the cable MS Os that Rembrandt has accused of infringement.

Answer: Rembrandt and Remstream admit that Rembrandt accused the entities listed in paragraph 48 of infringing the '234 patent. Rembrandt and Remstream admit that DOCSIS is a specification that describes operational parameters of equipment used for cable networks. Rembrandt and Remstream also admit that DOCSIS compliant cable modems and cable termination system ("CMTS") equipment, when used in conjunction with a cable company's cable network, infringe the '234 patent. Rembrandt and Remstream deny the remaining allegations of paragraph 48, except that Rembrandt and Remstream, after reasonable investigation, lack sufficient knowledge or information to admit or deny the truth of the allegations of the last sentence in paragraph 48.

49. An actual and justiciable controversy exists between Plaintiffs and Rembrandt regarding the infringement and validity of the '234 patent.

Answer: Admitted.

50. Plaintiffs have not infringed (directly or indirectly) any valid, enforceable claim of the '234 patent, either literally or under the doctrine of equivalents.

Answer: Denied.

51. The 234 patent is invalid because of its failure to meet the conditions of patentability and/or otherwise comply with the requirements of 35 U.S.C. §§ 101, 102, 103, and/or 112.

Answer: Denied.

52. A judicial declaration of noninfringement and invalidity is necessary and appropriate in order to resolve this controversy.

Answer: Denied.

**COUNT VI**  
**(Declaratory Judgment Action for a Declaration**  
**of Noninfringement and Invalidity of U.S. Patent No. 5,852,631)**

53. Paragraphs 1 through 22 are incorporated by reference as if stated fully herein.

Answer: Rembrandt and Remstream incorporate by reference their responses to paragraphs 1-52 as though fully set forth herein.

54. Rembrandt has accused Cablevision Systems Corporation, Charter Communications Operating, LLC, Charter Communications, Inc., Comcast Cable Communications, LLC, Comcast Corporation, Comcast of Plano, LP, Coxcom, Inc., CSC Holdings, Inc., Time Warner Cable Inc., Time Warner Cable LLC, Time Warner Entertainment-Advance/Newhouse Partnership, Time Warner Entertainment Company, L.P. and Time Warner New York Cable LLC of infringing the '631 patent because of the operational parameters of the cable equipment that they purchase for their cable systems. Specifically, Rembrandt has alleged that DOCSIS is a specification that describes operational parameters of equipment that is used for cable networks. Rembrandt further asserts that DOCSIS-compliant cable modem ("CM") and cable modem termination system ("CMTS") equipment allegedly infringe the '631 patent. Plaintiffs manufacture and sell accused CM and/or CMTS equipment, and each of the Plaintiffs has supplied accused CM and/or CMTS equipment to one or more of the cable MSOs that Rembrandt has accused of infringement.

Answer: Rembrandt and Remstream admit that Rembrandt accused the entities listed in paragraph 54 of infringing the '631 patent. Rembrandt and Remstream admit that DOCSIS is a specification that describes operational parameters of equipment used for cable networks. Rembrandt and Remstream also admit that DOCSIS compliant cable modems and cable termination system ("CMTS") equipment, when used in conjunction with a cable company's

cable network, infringe the '631 patent. Rembrandt and Remstream deny the remaining allegations of paragraph 54, except that Rembrandt and Remstream, after reasonable investigation, lack sufficient knowledge or information to admit or deny the truth of the allegations of the last sentence in paragraph 54.

55. An actual and justiciable controversy exists between Plaintiffs and Rembrandt regarding the infringement and validity of the '631 patent.

Answer: Admitted.

56. Plaintiffs have not infringed (directly or indirectly) any valid, enforceable claim of the '631 patent, either literally or under the doctrine of equivalents.

Answer: Denied.

57. The '631 patent is invalid because of its failure to meet the conditions of patentability and/or otherwise comply with the requirements of 35 U.S.C. §§ 101, 102, 103, and/or 112.

Answer: Denied.

58. A judicial declaration of noninfringement and invalidity is necessary and appropriate in order to resolve this controversy.

Answer: Denied.

**COUNT VII**  
**(Declaratory Judgment Action for a Declaration**  
**of Noninfringement and Invalidity of U.S. Patent No. 6,131,159)**

59. Paragraphs 1 through 22 are incorporated by reference as if stated fully herein.

Answer: Rembrandt and Remstream incorporate by reference their responses to paragraphs 1-58 as though fully set forth herein.

60. Rembrandt has accused Adelphia Communications Corporation, Century-TCI Distribution Company, LLC, Century-TCI California, LP, Century-TCJ California Communications, LP, Century-TCJ Holdings, LLC, Charter Communications Operating, LLC, Charter Communications, Inc., Comcast Cable Communications, LLC, Comcast Corporation, Comcast of Plano, LP, Coxcom, Inc., Parnassos Communications, LP, Parnassos Distribution Company I, LLC, Parnassos Distribution Company II, LLC, Parnassos Holdings, LLC, Parnassos, LP, Time Warner Cable Inc., Time Warner Cable LLC, Time Warner Entertainment-Advance/Newhouse Partnership, Time Warner Entertainment Company, L.P., Time Warner New York Cable LLC and Western NY Cablevision, LP of infringing the '159 patent because of the operational parameters of the cable equipment that they purchase for their cable systems. Specifically, Rembrandt has alleged that DOCSIS is a specification that describes operational parameters of equipment that is used for cable networks. Rembrandt further asserts that DOCSIS-compliant cable modem ("CM") and cable modem termination system ("CMTS") equipment allegedly infringe the '159 patent. Plaintiffs manufacture and sell accused CM and/or CMTS equipment, and each of Plaintiffs has supplied accused CM and/or CMTS equipment to one or more of the cable MSOs that Rembrandt has accused of infringement.

Answer: Rembrandt and Remstream admit that Rembrandt accused the entities listed in paragraph 60 of infringing the '159 patent. Rembrandt and Remstream admit that DOCSIS is a specification that describes operational parameters of equipment used for cable networks. Rembrandt and Remstream also admit that DOCSIS compliant cable modems and cable termination system ("CMTS") equipment, when used in conjunction with a cable company's cable network, infringe the '159 patent. Rembrandt and Remstream deny the remaining allegations of paragraph 60, except that Rembrandt and Remstream, after reasonable investigation, lack sufficient knowledge or information to admit or deny the truth of the allegations of the last sentence in paragraph 60.

61. An actual and justiciable controversy exists between Plaintiffs and Rembrandt regarding the infringement of the '159 patent.

Answer: Admitted.

62. Plaintiffs have not infringed (directly or indirectly) any valid, enforceable claim of the '159 patent, either literally or under the doctrine of equivalents.

Answer: Denied.

63. The 159 patent is invalid because of its failure to meet the conditions of patentability and/or otherwise comply with the requirements of 35 U.S.C. §§ 101, 102, 103, and/or 112.

Answer: Denied.

64. A judicial declaration of noninfringement and invalidity is necessary and appropriate in order to resolve this controversy.

Answer: Denied.

**COUNT VIII**  
**(Declaratory Judgment Action for a Declaration**  
**of Noninfringement and Invalidity of U.S. Patent No. 6,950,444)**

65. Paragraphs 1 through 22 are incorporated by reference as if stated fully herein.

Answer: Rembrandt and Remstream incorporate by reference their responses to paragraphs 1-64 as though fully set forth herein.

66. Rembrandt has accused Adelphia Communications Corporation, Century-TCI Distribution Company, LLC, Century-TCJ California, LP, Century-TCJ California Communications, LP, Century-TCI Holdings, LLC, Charter Communications Operating, LLC, Charter Communications, Inc., Comcast Cable Communications, LLC, Comcast Corporation, Comcast of Plano, LP, Coxcom, Inc., Parnassos Communications, LP, Parnassos Distribution Company I, LLC, Parnassos Distribution Company II, LLC, Parnassos Holdings, LLC, Parnassos, LP, Time Warner Cable Inc., Time Warner Cable LLC, Time Warner Entertainment-Advance/Newhouse Partnership, Time Warner Entertainment Company, L.P., Time Warner New York Cable LLC and Western NY Cablevision, LP of infringing the '444 patent because of the operational parameters of the cable equipment that they purchase for their cable systems. Specifically, Rembrandt has alleged that DOCSIS is a specification that describes operational parameters of equipment that is used for cable networks. Rembrandt further asserts that DOCSIS-compliant cable modem ("CM") and cable modem termination system ("CMTS") equipment allegedly infringe the '444 patent. Plaintiffs manufacture and sell accused CM and/or CMTS equipment, and each of Plaintiffs has supplied accused CM and/or CMTS equipment to one or more of the cable MSOs that Rembrandt has accused of infringement.

Answer: Rembrandt and Remstream admit that Rembrandt accused the entities listed in paragraph 66 of infringing the '444 patent. Rembrandt and Remstream admit that DOCSIS is a specification that describes operational parameters of equipment used for cable networks.



Rembrandt and Remstream also admit that DOCSIS compliant cable modems and cable termination system ("CMTS") equipment, when used in conjunction with a cable company's cable network, infringe the '444 patent. Rembrandt and Remstream deny the remaining allegations of paragraph 66, except that Rembrandt and Remstream, after reasonable investigation, lack sufficient knowledge or information to admit or deny the truth of the allegations of the last sentence in paragraph 66.

67. An actual and justiciable controversy exists between Plaintiffs and Rembrandt regarding the infringement and validity of the '444 patent.

Answer: Admitted.

68. Plaintiffs have not infringed (directly or indirectly) any valid, enforceable claim of the '444 patent, either literally or under the doctrine of equivalents.

Answer: Denied.

69. The '444 patent is invalid because of its failure to meet the conditions of patentability and/or otherwise comply with the requirements of 35 U.S.C. §§ 101, 102, 103, and/or 112.

Answer: Denied.

70. A judicial declaration of noninfringement and invalidity is necessary and appropriate in order to resolve this controversy.

Answer: Denied.

**COUNT IX**  
**(Declaratory Judgment Action for a Declaration**  
**of Patent Unenforceability Due to Inequitable Conduct)**

71. Paragraphs 1 through 22 are incorporated by reference as if stated fully herein.



Answer: Rembrandt and Remstream incorporate by reference their responses to paragraphs 1-70 as though fully set forth herein.

72. An actual and justiciable controversy exists between Plaintiffs and Defendants regarding the enforceability of the '819, '903, '761, '858, '234, '631, '159, and '444 patents (the "Fraudulently Obtained Patents").

Answer: Admitted that a justiciable controversy exists between Plaintiffs and Defendants regarding the enforceability of the '819, '903, '761, '858, '234, '631, '159, and '444 patents ("Patents-in-Suit"), and that the Patents-in-Suit are enforceable. Except as expressly admitted, the allegations of paragraph 72 of the Complaint are denied.

73. Individuals subject to the duty of candor under 37 C.F.R. 1.56 ("Applicants"), including named inventors in the applications referenced below and employees with substantive involvement in the filing and/or prosecution of patent applications for Paradyne entities, engaged in inequitable conduct by engaging in a pattern and practice of withholding or misstating material information with intent to deceive the United States Patent & Trademark Office ("USPTO") in connection with patent prosecution of the Fraudulently Obtained Patents. On multiple occasions, Applicants failed to disclose their own previously issued patents that comprised material prior art, failed to disclose material information regarding their own co-pending applications for patents, failed to disclose prior art that was known to them through the prosecution of their own patents and applications, and failed to disclose their own systems that implemented undisclosed, material prior art and that were on-sale prior to the relevant critical dates. In addition to nondisclosure, Applicants in the prosecution chain of the '159 and '234 patents provided affirmative misstatements as set forth below. Accordingly, Applicants engaged in an overall pattern and practice of repeatedly and continuously failing to disclose to the USPTO material information of which Applicants were indisputably aware. The permeation and continuation of this misconduct throughout prosecution of multiple patent applications confirms that Applicants acted with deceptive intent rendering the patents unenforceable. Further, the doctrine of infectious unenforceability renders related patents unenforceable.

Answer: Denied.

74. More specifically, during prosecution of the '761 patent, Applicants engaged in inequitable conduct before the USPTO, rendering the '761 patent unenforceable by withholding and failing to disclose material information with intent to deceive including the following acts:

- (i) By way of example, MPEP § 2001.06(b) states that "there is a duty to bring to the attention of the examiner, or other Office official involved with the examination of

a particular application, information within their knowledge as to other co-pending United States applications which are ‘material to patentability’ of the application in question.” The MPEP cites to case law providing that “[W]e think that it is unfair to the busy examiner, no matter how diligent and well informed he may be, to assume that he retains details of every pending file in his mind when he is reviewing a particular application . . . [T]he applicant has the burden of presenting the examiner with a complete and accurate record to support the allowance of letters patent.” The MPEP provides express examples of material information as to other co-pending applications, stating “[f]or example, if a particular inventor has different applications pending in which similar subject matter but patentable indistinct claims are present that fact must be disclosed to the examiner of each of the involved applications. Similarly, the prior art references from one application must be made of record in another subsequent application if such prior art references are ‘material to patentability’ of the subsequent application.”

- (ii) Notwithstanding these clear obligations, during prosecution, Applicants repeatedly failed to disclose material information within their knowledge as to co-pending applications of which they were aware. One or more applicants were aware of and failed to disclose, without limitation, co-pending application 08/780,762 (now the ‘631 patent, which is now commonly asserted here along with the ‘761 patent), as well as Application Nos. 08/78 1,787, now issued as U.S. Patent No. 5,751,796 (“Rapid Startup Protocol For Communication Between a Plurality of Modems”), to Scott and Zuranski, 08/781,067 now issued as U.S. Patent No. 5,796,808 (“System and Method for Automatically Selecting the Mode of Communication between a Plurality of Modems”), to Scott and Lastinger Jr., 08/780,238, now issued as U.S. Patent No. 5,787,363 (“System and Method for Connect Message Synchronization of Modems in a Cellular Data Gateway”), to Scott and Lastinger Jr., 08/457,881, now issued as U.S. Patent No. 5,793,809 (“Transparent Technique for Mu-Law Modems to Detect an All-Digital Circuit Connection”), to Holmquist, 08/912,126, now issued as U.S. Patent No. 6,081,556 (“Transparent Technique for Mu-Law Modems to Detect an All-Digital Circuit Connection”), to Holmquist, and 08/978,536, now issued as U.S. Patent No. 5,349,635 (“Half-Duplex or Full-Duplex Automode Operation for use in Data Communications Equipment”), to Scott (the “‘761 Co-Pending Applications”). The Applicants for the ‘761 patent failed to identify any of these co-pending applications or their claims to the examiner in the prosecution of the ‘761 patent. These applications were never disclosed on any IDS that was submitted in the ‘761 patent or otherwise made of record in the ‘761 patent. Information relating to the ‘761 Co-Pending Applications and their claims was material to patentability. One or more Applicants were aware of the ‘761 Co-Pending Applications. Four of the ‘761 Co-Pending Applications include Robert Scott as a named inventor, and in the case of the ‘761 and ‘631 patents, he is the sole named inventor on both. Robert Scott was aware of the co-pendency of his applications. In addition, on information and belief, a reasonable opportunity for discovery will show that Paradyne personnel were substantively involved in the filing or prosecution of the ‘761 patent and were aware of the ‘761 Co-Pending Applications. Material information relating to

the '761 Co-Pending Applications was withheld with intent to deceive the USPTO as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.

- (iii) Further, Applicants failed to disclose in prosecution of the '761 patent, the prior art of record from the '761 Co-Pending Applications, including without limitation U.S. Patent Nos. 4,905,282 ("Feature Negotiation Protocol and Dynamically Adjustable Retraining Sequence for a High Speed Half Duplex Modem"), to McGlynn and Nash ("McGlynn"), 5,425,080 ("Transaction Terminal Apparatus and Method Using Host Dial String Control of Modem Connect Protocols"), to Abbie ("Abbie"), 4,931,250 ("Multimode Modem"), to Greszczuk ("Greszczuk"), 5,491,720 ("Method and System for Automatically Determining Data Communication Device Type and Corresponding Transmission Rate"), to Davis, Linger, Mandalia, Sinibaldi, Zevin, and Ziegenhain ("Davis"), 5,311,578 ("Technique for Automatic Identification of a Remote Modem"), to Bremer ("Bremer et al."), 5,317,594 ("Systems for and Method of Identifying V.Fast Modem Within Existing Automatic Interworking Procedure Standards"), to Goldstein ("Goldstein"), 5,528,679 ("Automatic Detection of Digital Call Paths in a Telephone System"), to Taarud ("Taarud"), 4,680,773 ("Data Telecommunications System"), to Amundsen ("Amundsen"), and 4,782,498 ("Modem with Improved Handshaking Capability"), to Copeland, HI ("Copeland") (the "'761 Co-Pending Art"). The '761 Co-Pending Art was material to the patentability of the '761 patent. Applicants for the '761 patent failed to identify any '761 Co-Pending Art to the examiner in the prosecution of the '761 patent. For example, McGlynn, Abbie, Greszczuk, Davis and Goldstein were each cited by the Examiner of the '631 patent in a Detailed Office Action and accompanying Notice of References Cited mailed on 9/12/97. Further, Greszczuk was cited in the 08/781,067 application on an IDS submitted on August 12, 1997, and in the 08/781,787 application on an IDS submitted October 6, 1997. The '761 patent was still pending and did not issue until January 20, 1998. One or more Applicants were aware of the '761 Co-Pending Art. Robert Scott is the same and only named inventor on both the '631 and the '761 patents. In addition, on information and belief, a reasonable opportunity for discovery will show that Paradyne personnel substantively involved in the filing or prosecution of the '761 patent were aware of the '761 Co-Pending Art, as well as U.S. Patent Nos. 5,600,712 ("Enabling Technique for Quickly Establishing High Speed PSTN Connections In Telecommuting Applications"), to Hanson, 5,577,105 ("Telephone Call Routing and Switching Techniques for Data Communications"), to Baum, 5,127,041 ("System and Method for Interfacing Computers to Diverse Telephone Networks"), to O'Sullivan, and Weismann, et al., "Interoperable Wireless Data," IEEE Communications Magazine, vol. 31, No. 2, pp. 68-77. In fact, while the '761 patent remained co-pending, Applicants attempted to distinguish prior art of record in the '631 patent, including transmitting a First Response with Amendments on October 23, 1997. Notwithstanding the October 23, 1997 response, the USPTO issued a Detailed Action rejecting the claims in the '631 patent based upon prior art to McGlynn in an office action dated November 18,

1997, while the application for the '761 patent remained co-pending, and Applicants nevertheless failed to disclose McGlynn in prosecution of the '761 patent. Further, Applicants for the '761 patent failed to disclose in prosecuting the '761 patent the office actions and responses from the co-pending '631 patent and the prior art of record referenced in those office actions and responses. The undisclosed information described herein was material to patentability of the '761 patent. The undisclosed information described herein was material to patentability of the '761 patent and was withheld with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.

Answer: Denied. By way of further answer, the prosecution history of the '761 patent and the MPEP speak for themselves.

75. Additional instances of misconduct occurred in prosecution of the '631 patent, where Applicants engaged in inequitable conduct before the USPTO rendering the patent unenforceable by withholding and failing to disclose material information with intent to deceive including the following acts:

- (i) By way of example, MPEP § 2001.06(b) states that "there is a duty to bring to the attention of the examiner, or other Office official involved with the examination of a particular application, information within their knowledge as to other co-pending United States applications which are 'material to patentability' of the application in question." The MPEP cites to caselaw providing that "[W]e think that it is unfair to the busy examiner, no matter how diligent and well informed he may be, to assume that he retains details of every pending file in his mind when he is reviewing a particular application . . . [T]he applicant has the burden of presenting the examiner with a complete and accurate record to support the allowance of letters patent." The MPEP provides express examples of material information as to other co-pending applications, stating "[f]or example, if a particular inventor has different applications pending in which similar subject matter but patentably indistinct claims are present that fact must be disclosed to the examiner of each of the involved applications. Similarly, the prior art references from one application must be made of record in another subsequent application if such prior art references are 'material to patentability' of the subsequent application.
- (ii) Notwithstanding these clear obligations, during prosecution, Applicants repeatedly failed to disclose information within their knowledge as to co-pending applications of which they were aware, including without limitation co-pending application 08/458,048 (now the '761 patent, which is now commonly asserted here along with the '631 patent), as well as Application Nos. 08/781,787, now issued as U.S. Patent No. 5,751,796 ("Rapid Startup Protocol For Communication Between a Plurality of Modems") to Scott and Zuranski, 08/78 1,067 now issued



as U.S. Patent No. 5,796,808 (“System and Method for Automatically Selecting the Mode of Communication between a Plurality of Modems”), to Scott and Lastinger Jr., 08/780,238, now issued as U.S. Patent No. 5,787,363 (“System and Method for Connect Message Synchronization of Modems in a Cellular Data Gateway”), to Scoff and Lastinger Jr., 08/457,881, now issued as U.S. Patent 5,793,809 (“Transparent Technique for Mu-Law Modems to Detect an All-Digital Circuit Connection”), to Holmquist, and 08/912,126, now issued as U.S. Patent No. 6,081,556 (“Transparent Technique for Mu-Law Modems to Detect an All-Digital Circuit Connection”), to Holmquist (the “‘631 Co-Pending Applications.”). Applicants for the ‘631 patent failed to identify any of these co-pending applications or their claims to the examiner in the prosecution of the ‘631 patent. These applications are never disclosed on an IDS that was submitted in the ‘631 patent or otherwise made of record in the ‘631 patent. One or more Applicants were aware of the ‘631 Co-Pending Applications during prosecution of the ‘631 patent. Three of the ‘631 Co-Pending Applications include Robert Scoff as a named inventor and claim priority to the same provisional applications for which priority is claimed by the ‘631 patent. In addition, on information and belief a reasonable opportunity for discovery will show that further Paradyne personnel were substantively involved in the filing or prosecution of the ‘631 patent and were aware of the ‘631 Co-Pending Applications. The information relating to the ‘631 Co-Pending Applications was material to the patentability of the ‘631 Patent and was withheld with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.

- (iii) Further, Applicants failed to disclose in prosecution of the ‘631 patent, the prior art of record from the ‘631 Co-Pending Applications, including without limitation U.S. Patent Nos. 5,550,881 (“Automatic Modulation Mode Selecting Unit and Method for Modems”), to Sridhar and Sheer (“Sridhar”), ‘578 Bremer et al. (“Bremer”), 5,430,793 (“Apparatus and Method for Configuring a Computer System and a Modem for use in a Particular Country”), to Ueltzen, Mahan, and Horn (“Ueltzen”), 4,715,044 (“Automatic Synchronous/Asynchronous Modem”), to Gartner (“Gartner”), and 5,528,679 (“Automatic Detection of Digital Call Paths in a Telephone System”), to Taarud (“Taarud”) (the “‘631 Co-Pending Art”). The Applicants did not disclose the ‘631 Co-Pending Art during prosecution of the ‘631 patent. Applicants were aware of the ‘631 Co-Pending Art during prosecution of the ‘631 patent. Robert Scott is the same and only named inventor on both the ‘631 and the ‘761 patents. In addition, on information and belief a reasonable opportunity for discovery will show that further Paradyne personnel substantively involved in the filing or prosecution of the ‘631 patent were aware of the ‘631 Co-Pending Art, as well as U.S. Patent Nos. 5,349,635 (“Half-Duplex or Full-Duplex Automode Operation for use in Data Communications Equipment”), to Scoff, 5,600,712 (“Enabling Technique for Quickly Establishing High Speed PSTN Connections In Telecommuting Applications”), to Hanson, 5,577,105 (“Telephone Call Routing and Switching Techniques for Data Communications”), to Baum, 5,127,041 (“System and Method for Interfacing

Computers to Diverse Telephone Networks”), to O’Sullivan, 4,680,773 (“Data Telecommunications System”), to Amundson (“Amundson”), and 4,782,498 (“Modem with Improved Handshaking Capability”), to Copeland, III (“Copeland”), and Weissman, et al., “Interoperable Wireless Data,” IEEE Communications Magazine, vol. 31, No. 2, pp. 68-77. For example, Sridhar et al. was cited by the Examiner of the ‘761 patent and used for claim rejections in a Detailed Office Action and accompanying Notice of References Cited dated December 26, 1996. Similarly, Ueltzen was “considered pertinent to applicant’s disclosure” in that same Detailed Office Action. The ‘631 and ‘761 patent were co-pending on December 26, 1996, and the ‘631 patent did not issue until December 22, 1998. While the ‘631 patent remained co-pending, Applicants attempted to distinguish prior art of record in the ‘761 patent in a Response and Amendment transmitted March 31, 1997. Applicants for the ‘631 patent failed to disclose in prosecuting the ‘631 patent, the December 26, 1996 office action and the March 31, 1997 response from the co-pending ‘761 patent or the prior art of record referenced in those communications. The ‘631 Co-Pending Art and information described in this paragraph was material to patentability of the ‘631 patent. The ‘631 Co-Pending Art and information described in this paragraph was withheld with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count. In addition, on information and belief, a reasonable opportunity for discovery will show that Robert Scoff was improperly listed as sole inventor of the ‘631 patent with deceptive intent to defraud the USPTO into issuing the ‘631 patent over the ‘761 patent.

Answer: Denied. By way of further answer, the prosecution history of the ‘631 patent and the MPEP speak for themselves.

76. Additional instances of misconduct occurred in prosecution of the ‘903 patent, where Applicants engaged in inequitable conduct before the USPTO rendering the patent unenforceable by withholding and failing to disclose material information with intent to deceive including the following acts:

- (i) The application for the ‘903 patent was filed on May 25, 1989, issued April 16, 1991, and named Betts and DesRosiers as inventors. One or more Applicants was aware of and failed to disclose in prosecution of the ‘903 patent the following prior art: U.S. Patent Nos. 4,771,232 (“Non-interruptive Spectrum Analyzer for Digital Modems”), to Betts and Zuranski, 4,555,790 (“Digital Modem Having A Monitor For Signal-To-Noise Ratio”), to Betts and Martinez, 4,811,357 (“Secondary Channel for Digital Modems Using Spread Spectrum Subliminal Induced Modulation”), to Betts and Zuranski, 4,833,690 (“Remote Eye Pattern Display For Digital Modems”), to Belts, Zuranski, Springer, and Balka, 4,639,934 (“Line Impairment Display for Digital Modems”), to Betts, Scott and Zuranski, 4,646,325 (“Index Decoder for Digital Modems”), to Zuranski and Martinez,

3,889,108 (“Adaptive Low Pass Filter”), to Cantrell, 4,669,090 (“Half-Duplex Modem without Turnaround Delay”), to Betts and Martinez, 4,744,092 (“Transparent Error Detection in Half Duplex Modems”), to Betts and Martinez, 4,532,640 (“Phase Tracking Loop for Digital Modem”), to Bremer, Betts, and Martinez, 4,796,279 (“Substrate Preamble Decoder For A High Speed Modem”), to Betts and Martinez (collectively, the “‘903 Undisclosed References”). One or more Applicants was aware of the ‘903 Undisclosed References during prosecution of the ‘903 patent. For example, Belts is a named inventor in multiple ‘903 Undisclosed References. In addition, on information and belief a reasonable opportunity for discovery will show that Paradyne personnel substantively involved in the filing or prosecution of the ‘903 patent were aware of the ‘903 Undisclosed References. The ‘903 Undisclosed References were not disclosed to the USPTO in prosecution of the ‘903 patent. The ‘903 Undisclosed References were material to patentability of the ‘903 patent. The ‘903 Undisclosed References were withheld with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count. In addition, on information and belief, a reasonable opportunity for discovery will show that one or more Applicants was aware of the 3,978,407 (“Fast Start-Up Adaptive Equalizer Communication System Using Two Data Transmission Rates”), to Forney and Hart (the “‘407 patent”), a patent issued to a competitor of Paradyne. The ‘407 patent was material to patentability. On information and belief, a reasonable opportunity for discovery will show that the ‘407 patent was withheld with intent to deceive in light of the overall pattern and practice of nondisclosure.

Answer: Denied. By way of further answer, the prosecution history of the ‘903 patent and the MPEP speak for themselves.

77. Additional instances of misconduct occurred in prosecution of the ‘444 patent, where Applicants engaged in inequitable conduct before the USPTO rendering the patent unenforceable by withholding and failing to disclose material information with intent to deceive including the following acts:

- (i) By way of example, MPEP § 2001.06(b) states that “there is a duty to bring to the attention of the examiner, or other Office official involved with the examination of a particular application, information within their knowledge as to other co-pending United States applications which are ‘material to patentability’ of the application in question.” The MPEP cites to caselaw providing that “[W]e think that it is unfair to the busy examiner, no matter how diligent and well informed he may be, to assume that he retains details of every pending file in his mind when he is reviewing a particular application.. . [T]he applicant has the burden of presenting the examiner with a complete and accurate record to support the allowance of letters patent.” The MPEP provides express examples of material information as to other co-pending applications, stating “[f]or example, if a



particular inventor has different applications pending in which similar subject matter but patentably indistinct claims are present that fact must be disclosed to the examiner of each of the involved applications. Similarly, the prior art references from one application must be made of record in another subsequent application if such prior art references are material to patentability' of the subsequent application."

- (ii) Notwithstanding these clear obligations, during prosecution, Applicants repeatedly failed to disclose information within their knowledge as to co-pending applications of which they were aware, including without limitation co-pending Application No. 8/980,996 (the "Co-Pending '996 Application"). The Co-Pending '996 Application, which subsequently issued as U.S. Patent 6,414,964 ("Method and Apparatus for Performing a Multipoint Polling Protocol which Employs Silence Intervals for Controlling Circuit Operation"), and names Holmquist and Betts as inventors, and was filed on December 1, 1997 and issued on July 2, 2002. The application for the '444 patent was filed on August 11, 2000, and issued September 27, 2005, and named Holmquist and Chapman as inventors. In addition, Applicants failed to disclose in the prosecution of the '444, material prior art of record from the Co-Pending '996 Application, including without limitation U.S. Patent No. 5,677,909 ("Apparatus For Exchanging Data Between A Central Station And A Plurality of Wireless Remote Stations On A Time Divided Channel"), issued to Heide. One or more Applicants was aware of the above-referenced information during prosecution of the '444 patent. The undisclosed information referenced in this paragraph was material to patentability of the '444 patent. Applicants failed to disclose this material information relating to this co-pending application with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.
- (iii) By way of further example, Application 09/307,454 filed May 7, 1999 for a "System and Method For Transmitting Special Marker Symbol" (subsequently issued as U.S. Patent No. 6,487,244) and Application No. 08/979,455, subsequently issued as U.S. Patent No. 6,137,829 (the "'444 Co-Pending '454 and '455 Applications"), were also co-pending with the '444 patent. The '444 Co-Pending '454 and '455 Applications of Betts comprised prior art to the '444 Patent and were not disclosed to the USPTO in prosecution of the '444 Patent. One or more Applicants was aware of the '444 Co-Pending '454 and '455 Applications during prosecution of the '444 patent. The '444 Co-Pending '454 and '455 applications were material to patentability of the '444 patent and withheld with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.
- (iv) By way of further example, during prosecution of the '444 patent application, Applicants repeatedly failed to disclose information within their knowledge as to material prior art of which they were aware, including without limitation 5,506,866 ("Side-Channel Communications In Simultaneous Voice and Data

Transmission”), to Bremer, Holmquist, Ko, and Sonders, 5,475,691 (“Voice Activated Data Rate Change in Simultaneous Voice and Data Transmission”), to Chapman and Holmquist, 5,369,703 (“Command and Control Signalling Method and Apparatus”), to Archibald, Davis, and Holmquist, and 4,864,617 (“System and Method for Reducing Deadlock Conditions Caused By Repeated Transmission of Data Sequences Equivalent to Those Used for Inter-Device Signalling”), to Holmquist.

- (v) In addition, on information and belief, a reasonable opportunity for discovery will show that one or more Applicants was aware of U.S. Patent Nos. 3,978,407 (“Fast Start-Up Adaptive Equalizer Communication System Using Two Data Transmission Rates”), to Forney and Hart, 4,796,279 (“Substrate Preamble Decoder For A High Speed Modem”), to Betts and Martinez, and 5,912,895 (“Information Network Access Apparatus and Methods for Communicating Information Packets Via Telephone Lines”), to Terry and Richards. Applicants failed to disclose these patents to the USPTO in prosecution of the ‘444 patent. These references were material to patentability of the ‘444 patent. On information and belief, a reasonable opportunity for discovery will show that Applicants knew of and withheld them with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.
- (vi) In addition, on information and belief a reasonable opportunity for discovery will show that Paradyne offered for sale MVL technology more than one year before applying for the ‘444 patent, that was material to the ‘444 patent, but failed to disclose those sales as prior art to the USPTO. The withheld information was material to patentability and, on information and belief a reasonable opportunity for discovery will show that this information was withheld with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.

Answer: Denied. By way of further answer, the prosecution history of the ‘444 patent and the MPEP speak for themselves.

78. Additional instances of misconduct occurred during prosecution of the ‘159 patent, where Applicants engaged in inequitable conduct before the USPTO rendering the patent unenforceable by omitting and misstating material information with intent to deceive including the following acts:

- (i) In prosecution of the ‘159 patent, the USPTO repeatedly rejected pending claims due to prior art, including without limitation references to Lang and Mon. In response to these and other rejections, Applicants represented that claims required and that they had invented a system that included a “displacement multibit memory address.” However, Applicants lacked support for the invention as represented to the USPTO. Applicants misstated and omitted this material

information with intent to deceive the USPTO into issuing the claims. These material misstatements and omissions were made with intent to deceive, as further confirmed by the pattern and practice of inequitable conduct alleged throughout this Count. Further, the '234 patent is a divisional of the '159 patent, refers back to acts occurring in prosecution of the '159 patent, and is infected by the unenforceability associated with the '159 patent.

- (ii) In addition, on information and belief, a reasonable opportunity for discovery will show that the Applicants offered the invention on-sale or placed it in public use more than one year before the application date, and applicants withheld this information which was material to patentability with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.

Answer: Denied. By way of further answer, the prosecution history of the '159 patent and the MPEP speak for themselves.

79. Additional instances of misconduct occurred in prosecution of the '858 patent, Applicants engaged in inequitable conduct before the USPTO rendering the patent unenforceable by withholding and failing to disclose material information with intent to deceive including the following acts:

- (i) By way of example, MPEP § 2001.06(b) states that "there is a duty to bring to the attention of the examiner, or other Office official involved with the examination of a particular application, information within their knowledge as to other co-pending United States applications which are 'material to patentability' of the application in question." The MPEP cites to caselaw providing that "[W]e think that it is unfair to the busy examiner, no matter how diligent and well informed he may be, to assume that he retains details of every pending file in his mind when he is reviewing a particular application . . . [T]he applicant has the burden of presenting the examiner with a complete and accurate record to support the allowance of letters patent." The MPEP provides express examples of material information as to other co-pending applications, stating "[f]or example, if a particular inventor has different applications pending in which similar subject matter but patentably indistinct claims are present that fact must be disclosed to the examiner of each of the involved applications. Similarly, the prior art references from one application must be made of record in another subsequent application if such prior art references are 'material to patentability' of the subsequent application."
- (ii) Notwithstanding these clear obligations, during prosecution, Applicants failed to disclose information as to co-pending applications including without limitation Application Nos. 08/607,912, now issued as U.S. Patent No. 5,754,799 ("System and Method for Bus Contention Resolution"), to Hiles, 08/608,378 now issued as

5,768,543 (“Slot-Token Protocol”), to Jules, and 08/947,279, now issued as 6,108,347 (“Non-Polled Dynamic Slot Time Allocation Protocol”) to Holmquist, (the “‘858 Co-Pending Applications.”). The Applicants for the ‘858 patent failed to identify any of these co-pending applications or their claims to the examiner in the prosecution of the ‘858 patent. On information and belief, a reasonable opportunity for discovery will show that Applicants were aware of the ‘858 Co-Pending Applications during prosecution of the ‘858 patent. These co-pending applications and their claims were material to the patentability. On information and belief, a reasonable opportunity for discovery will show that this undisclosed information was withheld with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.

- (iii) Further, Applicants failed to disclose in prosecution of the ‘858 patent, the material prior art of record from the ‘858 Co-Pending Applications, including without limitation U.S. Patent Nos. 4,608,700 (“Serial Multi-Drop Data Link”), to Kirtley, Sterling, and Williams, and 5,398,243 (“Arbitration Method and Bus for Serial Data Transmission”), to Aguilhon, Doucet, and Karcher (the “‘858 Co-Pending Art”). The Applicants did not disclose the ‘858 Co-Pending Art during prosecution of the ‘858 patent. On information and belief, a reasonable opportunity for discovery will show that one or more Applicants was aware of the ‘858 Co-Pending Art during prosecution of the ‘858 patent. This undisclosed information was material to patentability of the ‘858 patent. On information and belief, a reasonable opportunity for discovery will show this information was withheld with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.
- (iv) In addition, one or more Applicants was aware of U.S. Patent No. 4,797,815 (“Interleaved Synchronous Bus Access Protocol for a Shared Memory Multi-Processor System”), to Moore (the same inventor as the ‘858), and, on information and belief, a reasonable opportunity for discovery will show one or more Applicants was aware of U.S. Patent Nos. 3,997,896 (“Data Processing System Providing Split Bus Cycle Operation”), to Cassarino, Jr., Bekampis, Conway, and Lemay, 4,181,974 (“System Providing Multiple Outstanding Information Requests”), to Lemay and Curley, and 4,669,056 (“Data Processing System with a Plurality of Processors Accessing a Common Bus to Interleaved Storage”), to Waldecker and Wright. Applicants failed to disclose these patents to the USPTO in prosecution of the ‘858 patent. These reference were material to patentability of the ‘858 patent and on information and belief a reasonable opportunity for discovery will show that Applicants knew of and withheld them with intent to deceive the USPTO, as is particularly shown by the continuing pattern and practice of nondisclosure referenced in this Count.
- (v) Further, in the prosecution of the ‘858 patent, the Applicants failed to disclose the previously issued ‘819 patent also assigned to Paradyne. In light of Defendants’ allegations in this matter, the ‘819 patent was material to the ‘858 patent. On



information and belief, a reasonable opportunity for discovery will show that one or more Applicants was aware of the '819 patent and Applicants' nondisclosure of the '819 patent, in light of the pattern and practice alleged throughout this Count, occurred with the requisite intent to deceive the USPTO into issuing the '858 patent.

Answer: Denied. By way of further answer, the prosecution history of the '858 patent and the MPEP speak for themselves.

80. Additional instances of misconduct occurred in prosecution of the '819 patent, where Applicants failed to disclose previously issued and material prior art U.S. Patent No. 4,630,286 ("Device for Synchronization of Multiple Telephone Circuits"), assigned to Paradyne Corporation. On information and belief, a reasonable opportunity for discovery will show that one or more Applicants was aware of this undisclosed reference during prosecution and that Applicants' nondisclosure of the 4,630,286 patent, in light of the pattern and practice alleged throughout this Count, occurred with the requisite intent to deceive the USPTO into issuing the '819 patent.

Answer: Denied.

**COUNT X**  
**(Declaratory Judgment Action for a Declaration of Unclean Hands)**

81. Paragraphs 1 through 80 are incorporated by reference as if stated fully herein.

Answer: Rembrandt and Remstream incorporate by reference their responses to paragraphs 1-80 as though fully set forth herein.

82. Rembrandt's claims are barred by unclean hands. Rembrandt asserts the patents identified in Courts I through VIII despite its awareness of the nondisclosures described in the inequitable conduct allegations. Rembrandt asserts to have acquired a portfolio of patents previously assigned to Paradyne. Rembrandt has consulting agreements with all named inventors on all of the patents-in-suit. Further, prior to making charges against Plaintiffs, Rembrandt communicated with one or more additional Paradyne personnel who had substantive involvement in the filing or prosecution of Paradyne patent applications. Rembrandt is aware of the undisclosed and material information referred to in Counts I through IX above through Rembrandt's alleged acquisition of a portfolio of patents assigned to Paradyne and its assertion of the patents in this case. In fact, after originally filing lawsuits on four patents including the '631 patent, Rembrandt later filed lawsuits specifically adding the '761 patent, specifically alleging infringement of both patents by the same accused instrumentalities. Rembrandt was aware of the co-pendency of those patents as well as their prosecution histories, and the cited art

and office actions, and nevertheless specifically endeavored to assert both patents. Rembrandt's knowing assertion of unenforceable patents comprises unclean hands.

Answer: Denied. By way of further answer, it is admitted that Rembrandt has asserted the Patents-in-Suit, acquired certain patents from Paradyne, and has consulting agreements with certain of the named inventors on certain Patents-in-Suit. Except as expressly admitted, the allegations of paragraph 82 are denied.

### **AFFIRMATIVE DEFENSES**

#### **First Affirmative Defense**

Plaintiffs' counterclaims fail to state a claim upon which relief may be granted.

#### **Second Affirmative Defense**

Plaintiffs' counterclaims are barred, in whole or in part, by the doctrine of estoppel.

#### **Third Affirmative Defense**

Plaintiffs' counterclaims are barred, in whole or in part, by the doctrine of waiver.

#### **Fourth Affirmative Defense**

Plaintiffs' counterclaims are barred, in whole or in part, by applicable limitations doctrines, including the statute of limitations.

#### **Fifth Affirmative Defense**

Plaintiffs' counterclaims are based on a purported agreement to agree, which is unenforceable under applicable law.

#### **Sixth Affirmative Defense**

Plaintiffs' counterclaims are based upon a purported agreement with open essential terms, which cannot be supplied under applicable law.



**Seventh Affirmative Defense**

To the extent there was an enforceable promise, it was solely a promise to negotiate; there was no intention to permit any third party or a court to impose licensing terms.

**Eighth Affirmative Defense**

Plaintiffs' counterclaims are barred by the doctrine of laches.

**Ninth Affirmative Defense**

Plaintiffs' counterclaims fail as a matter of law based on a lack of contractual privity between Rembrandt and Plaintiffs involving any alleged contractually binding obligation entered into by AT&T and/or AT&T IPM.

**Tenth Affirmative Defense**

Plaintiffs' counterclaims fail as a matter of law because Plaintiffs materially breached and/or repudiated any express or implied contract, thereby excusing Rembrandt from any alleged obligation that it might otherwise have had.

**Eleventh Affirmative Defense**

Plaintiff is not entitled to the relief requested as a matter of law.

**Twelfth Affirmative Defense**

Plaintiffs' counterclaims fail, in whole or in part, because Plaintiffs failed to fulfill conditions precedent to any obligation to offer a license to it.

**Thirteenth Affirmative Defense**

Rembrandt reserves the right to assert additional and/or different affirmative defenses as discovery progresses, and hereby reserves the right to amend its Answer to Plaintiffs' Amended Complaint in support of any such defenses.

**PRAYER FOR RELIEF**

WHEREFORE, Rembrandt and Remstream respectfully request: (i) that judgment be entered in their favor, and against Plaintiffs, on Plaintiffs' Amended Complaint, and that Plaintiffs not be awarded any relief in connection therewith; and (ii) that Rembrandt and Remstream be awarded all the relief sought in the Prayer for Relief of their Counterclaims, which is incorporated herein by reference.

**REMBRANDT TECHNOLOGIES, LP AND  
REMBRANDT TECHNOLOGIES, LLC'S  
COUNTERCLAIM FOR PATENT INFRINGEMENT**

Defendant/counter-plaintiffs Rembrandt Technologies, LP ("Rembrandt") and Rembrandt Technologies, LLC, d/b/a Remstream ("Remstream"), by and through the undersigned attorneys, assert the following counterclaims against Plaintiffs/Counter-Defendants, MSO Counter-Defendants and Sharp under the United States Patent Act, 35 U.S.C. § 1 *et seq.*, as follows:

**THE PARTIES**

1. Rembrandt is a limited partnership organized under the laws of the state of New Jersey with its principal place of business at 401 City Avenue, Suite 900, Bala Cynwyd, PA 19004.
2. Rembrandt Technologies, LLC, a Delaware LLC, is wholly owned by Rembrandt and does business as "Remstream." Remstream has its headquarters at 401 City Avenue, Suite 900, Bala Cynwyd, PA 19004.

3. Rembrandt has granted Remstream the exclusive right, under the '761, '234, '159, and '444 patents, to make, have made, import, sell, offer to sell, or otherwise distribute, DOCSIS 1.0/1.1, 2.0 and/or 3.0 compliant cable modems and/or EMTA cable modems.

4. Plaintiff/counter-defendant Ambit Microsystems, Inc. ("Ambit") is a California corporation with its principal place of business at 9570 La Costa Lane, Lone Tree, CO 80124.

5. Plaintiff/counter-defendant ARRIS Group, Inc. ("ARRIS") is a Delaware corporation with its principal place of business at 3871 Lakefield Drive, Suwanee, GA 30024.

6. Plaintiff/counter-defendant Cisco Systems, Inc. ("Cisco") is a California corporation with its principal place of business at 170 West Tasman Drive, San Jose, CA 95134.

7. Plaintiff/counter-defendant Motorola, Inc. ("Motorola") is a Delaware corporation with its principal place of business at 1303 Algonquin Road, Schaumburg, IL 60196.

8. Plaintiff/counter-defendant NETGEAR, Inc. ("NETGEAR") is a Delaware corporation with its principal place of business at 4500 Great America Parkway, Santa Clara, CA 95054.

9. Plaintiff/counter-defendant Scientific-Atlanta, Inc. ("Scientific-Atlanta") is a wholly-owned subsidiary of Plaintiff/Counter-Defendant Cisco and is a Georgia corporation with its principal place of business at 5030 Sugarloaf Parkway, Lawrenceville, GA 30044-2896.

10. Plaintiff/counter-defendant Thomson, Inc. ("Thomson") is a Delaware corporation with its principal place of business at 101 W. 103rd Street, INH 3340, Indianapolis, IN 46290.

11. Plaintiff/Counter-Defendants manufacture and/or sell cable equipment, including cable modems, to multiple system operators ("MSOs"), including but not limited to MSO Counter-Defendants. MSO Counter-Defendants sell and/or lease some of the cable equipment

and/or include the equipment in their networks for the provision of high speed internet, cable broadband, and/or other services.

12. Counter-defendant Time Warner Cable, Inc. ("TWC") is a corporation organized under the laws of the state of Delaware with its principal place of business at 7910 Crescent Executive Drive, Suite 56, Charlotte, North Carolina 28217. TWC's registered agent for service of process in Delaware is The Corporation Trust Company, 1209 Orange Street, Wilmington, DE 19801.

13. Counter-defendant Time Warner Cable LLC ("TWCL") is a limited liability company organized under the laws of the state of Delaware with its principal place of business at 290 Harbor Drive, Stamford, Connecticut 06902. TWCL's registered agent for service of process is the Corporation Trust Company, Corporation Trust Center, 1209 Orange Street, Wilmington, Delaware 19801.

14. Counter-defendant Time Warner NY Cable LLC ("TWN") is a limited liability company organized under the laws of the state of Delaware with its principal place of business at 7910 Crescent Executive Drive, Suite 56, Charlotte, North Carolina 28217. TWNY's registered agent for service of process in Delaware is The Corporation Trust Company, 1209 Orange Street, Wilmington, DE 19801.

15. Counter-defendant Time Warner Entertainment-Advance/Newhouse Partnership ("TWEAN") is a New York partnership having its corporate headquarters at One Time Warner Center, New York, NY 10019.

16. Counter-defendant Time Warner Entertainment Company, LP ("TWE") is a limited partnership organized under the laws of the state of Delaware with its principal place of business at 290 Harbor Drive, Stamford, Connecticut 06902 in care of Time Warner Cable.

TWE's registered agent for service of process in Delaware is The Corporation Trust Company, 1209 Orange Street, Wilmington, DE 19801.

17. Counter-defendant TWC is the direct or indirect parent of each of counter-defendants TWCL, TWNY, TWEAN and TWE. Through one or more of its subsidiaries, affiliates, partners, or other related parties, TWC owns and/or operates cable systems throughout the United States. TWCL, TWNY, TWEAN and TWE, each directly or through one or more subsidiaries, affiliates, partners, or other related parties, as set forth herein, have each committed and continue to commit tortuous acts of patent infringement.

18. Counter-defendant Comcast Corporation is a corporation organized under the laws of the state of Pennsylvania with its principal place of business at 1500 Market Street, Philadelphia, Pennsylvania 19103. Comcast Corporation is a national provider of cable television and internet products and services, and regularly conducts and transacts business in Delaware.

19. Counter-defendant Comcast Cable Communications, LLC is a limited liability company organized under the laws of Delaware with its principal place of business at 1500 Market Street, Philadelphia, Pennsylvania 19103. Comcast Cable Communications, LLC's registered agent for service of process in Delaware is Comcast Capital Corporation, 1201 N. Market Street, Suite 1000, Wilmington, DE 19801.

20. Counter-defendant Comcast Cable Communications Holdings, Inc. is a corporation organized under the law of the state of Delaware, having its principal place of business at One Comcast Center, Philadelphia, PA 19103. Comcast Cable Communications Holdings, Inc.'s registered agent for service of process in Delaware is Comcast Capital Corporation, 1201 N. Market Street, Suite 1000, Wilmington, DE 19801.

21. Counter-defendants Comcast Corporation, Comcast Cable Communications, LLC and Comcast Cable Communications Holdings, Inc. are collectively referred to as “Comcast.” Comcast is a national provider of cable television and internet products and services, and regularly conducts and transacts business in Delaware.

22. Counter-defendant Charter Communications, Inc. is a corporation organized under the laws of the state of Delaware with its principal place of business at 12405 Powerscout Drive, Ste. 100, St. Louis, Missouri 63131. Charter Communications, Inc. is a national provider of cable television and internet products and services, and regularly conducts and transacts business in Delaware. Charter Communications, Inc.’s registered agent for service of process in Delaware is Corporation Service Company, 2711 Centerville Road, Suite 400, Wilmington, DE 19808.

23. Counter-defendant Charter Communications Operating, LLC is a limited liability company organized under the laws of the state of Delaware with its principal place of business at 12405 Powerscout Drive, Ste. 100, St. Louis, Missouri 63131. Charter Communications Operating, LLC is a subsidiary of Counter-Defendant Charter Communications, Inc. and is a national provider of cable television and internet products and services, and regularly conducts and transacts business in Delaware. Charter Communications Operating, LLC’s registered agent for service of process in Delaware is Corporation Service Company, 2711 Centerville Road, Suite 400, Wilmington, DE 19808.

24. Counter-defendant Coxcom, Inc. is a corporation organized under the laws of the state of Delaware with its principal place of business at 1400 Lake Hearn Drive, Atlanta, Georgia 30319. Coxcom, Inc. is a national provider of cable television and internet products and services, and regularly conducts and transacts business in Delaware. Coxcom Inc.’s registered



agent for service of process in Delaware is Corporation Service Company, 2711 Centerville Road, Suite 400, Wilmington, DE 19808

25. Counter-defendant CSC Holdings, Inc. is a corporation organized under the laws of the state of Delaware with its principal place of business at 1111 Stewart Avenue, Bethpage, New York 11714. CSC Holdings, Inc.'s registered agent for service of process in Delaware is The Prentice-Hall Corporation System Inc., 2711 Centerville Road, Suite 400, Wilmington, DE 19808.

26. Counter-defendant Cablevision Systems Corporation is a corporation organized under the laws of the state of Delaware with its principal place of business at 1111 Stewart Avenue, Bethpage, New York 11714. Cablevision Systems Corporation's registered agent for service of process in Delaware is Corporation Service Company, 2711 Centerville Road, Suite 400, Wilmington, DE 19808.

27. Counter-defendant Adelphia Communications Corporation ("ACC") is a corporation organized under the laws of the state of Delaware. On June 25, 2002, ACC filed a petition in bankruptcy under Chapter 11 in the United States Bankruptcy Court for the Southern District of New York in a case captioned *In re Adelphia Communications Corporation*, Case No. 02-41729 (REG). That case remains pending in the bankruptcy court. ACC's principal place of business on the Petition Date was located in Coudersport, Pennsylvania and is currently located in Greenwood Village, Colorado. ACC was one of the leading cable and telecommunication companies in the United States. After seeking bankruptcy protection on June 25, 2002, ACC continued to provide cable internet and television services to consumers throughout the United States until the sale of substantially all of its assets on July 31, 2006. ACC's registered agent for

service of process in Delaware is Corporation Service Company, 2711 Centerville Road, Suite 400, Wilmington, DE 19808.

28. Counter-defendant Century-TCI California Communications, LP is a partnership organized under the laws of the state of Delaware. Century-TCI California Communications, LP is an affiliate of ACC. On June 25, 2002, Century-TCI California Communications, LP filed a petition in bankruptcy under Chapter 11 in the United States Bankruptcy Court for the Southern District of New York. Century-TCI California Communications, LP's bankruptcy proceedings are jointly administered with *In re Adelfhia Communications Corporation*, Case No. 02-41729 (REG). Century-TCI California Communications, LP's registered agent for service of process in Delaware is Comcast Capital Corporation, 1201 N. Market Street, Suite 1000, Wilmington, DE 19081.

29. Counter-defendant Century-TCI Holdings, LLC is a corporation organized under the laws of the state of Delaware. Century-TCI Holdings, LLC is an affiliate of ACC. On June 25, 2002, Century-TCI California Communications, LP filed a petition in bankruptcy under Chapter 11 in the United States Bankruptcy Court for the Southern District of New York. Century-TCI Holdings, LLC's bankruptcy proceedings are jointly administered with *In re Adelfhia Communications Corporation*, Case No. 02-41729 (REG). Century-TCI Holdings, LLC's registered agent for service of process in Delaware is Comcast Capital Corporation, 1201 N. Market Street, Suite 1000, Wilmington, DE 19801.

30. Counter-defendant Comcast of Florida/Pennsylvania, L.P. (f/k/a Parnassos, LP) is a partnership organized under the laws of the state of Delaware. Parnassos, LP was or is an affiliate of ACC. On June 25, 2002, Parnassos, LP filed a petition in bankruptcy under Chapter 11 in the United States Bankruptcy Court for the Southern District of New York. Parnassos,

LP's bankruptcy proceedings are jointly administered with *In re Adelfhia Communications Corporation*, Case No. 02-41729 (REG). Comcast of Florida/Pennsylvania, L.P.'s registered agent for service of process in Delaware is Comcast Capital Corporation, 1201 N. Market Street, Suite 1000, Wilmington, DE 19801.

31. Counter-defendant Comcast of Pennsylvania II, L.P. (f/k/a Century-TCI California, L.P.), is a partnership organized under the laws of the state of Delaware. Century-TCI California, L.P. was or is an affiliate of ACC. On June 25, 2002, Century-TCI California, L.P. filed a petition in bankruptcy under Chapter 11 in the United States Bankruptcy Court for the Southern District of New York. Century-TCI California, LP's bankruptcy proceedings are jointly administered with *In re Adelfhia Communications Corporation*, Case No. 02-41729 (REG). Comcast of Pennsylvania II, L.P.'s registered agent for service of process in Delaware is Comcast Capital Corporation, 1201 N. Market Street, Suite 1000, Wilmington, DE 19801.

32. Counter-defendant Parnassos Communications, LP is a partnership organized under the laws of the state of Delaware. Parnassos Communications, LP is an affiliate of ACC. On June 25, 2002, Parnassos Communications, LP filed a petition in bankruptcy under Chapter 11 in the United States Bankruptcy Court for the Southern District of New York. Parnassos Communications, LP's bankruptcy proceedings are jointly administered with *In re Adelfhia Communications Corporation*, Case No. 02-41729 (REG). Parnassos Communications, LP's registered agent for service of process in Delaware is Comcast Capital Corporation, 1201 N. Market Street, Suite 1000, Wilmington, DE 19801.

33. Counter-defendant Adelfhia Consolidation, LLC, into which Parnassos Distribution Company I, LLC, Parnassos Distribution Company II, LLC, and Century-TCI Distribution Company, LLC, were merged, is a limited liability company organized under the

laws of the state of Delaware. Parnassos Distribution Company I, LLC, Parnassos Distribution Company, II, LLC, and Century-TCI Distribution Company, LLC were affiliates of ACC. On June 25, 2002, Century-TCI Distribution Company, LLC filed a petition in bankruptcy under Chapter 11 in the United States Bankruptcy Court for the Southern District of New York. On October 6, 2005, Parnassos Distribution Company I, LLC, and Parnassos Distribution Company, II, LLC filed petitions in bankruptcy under Chapter 11 in the United States Bankruptcy Court for the Southern District of New York. Parnassos Distribution Company I, LLC's, Parnassos Distribution Company II, LLC's, and Century-TCI Distribution Company, LLC's bankruptcy proceedings are jointly administered with *In re Adelphia Communications Corporation*, Case No. 02-41729 (REG). Adelphia Consolidation, LLC's registered agent for service of process in Delaware is Corporation service Company, 2711 Centerville Road, Suite 400, Wilmington, DE 19808.

34. Counter-defendant Parnassos Holdings, LLC, is a corporation organized under the laws of the state of Delaware. Parnassos Holdings, LLC is an affiliate of ACC. On June 25, 2002, Parnassos Holdings, LLC filed a petition in bankruptcy under Chapter 11 in the United States Bankruptcy Court for the Southern District of New York. Parnassos Holdings, LLC's bankruptcy proceedings are jointly administered with *In re Adelphia Communications Corporation*, Case No. 02-41729 (REG). Parnassos Holdings, LLC's registered agent for service of process in Delaware is Comcast Capital Corporation, 1201 N. Market Street, Suite 1000, Wilmington, DE 19801.

35. Counter-defendant Western NY Cablevision, LP is a partnership organized under the laws of the state of Delaware. Western NY Cablevision, LP is an affiliate of ACC. On June 25, 2002, Western NY Cablevision, LP filed a petition in bankruptcy under Chapter 11 in the

United States Bankruptcy Court for the Southern District of New York. Western NY Cablevision, LP's bankruptcy proceedings are jointly administered with *In re Adelphia Communications Corporation*, Case No. 02-41729 (REG). Western NY Cablevision, LP's registered agent for service of process in Delaware is Comcast Capital Corporation, 1201 N. Market Street, Suite 1000, Wilmington, DE 19801.

36. Counter-defendants ACC, Comcast of Florida/Pennsylvania, L.P. (f/k/a Parnassos, LP), Comcast of Pennsylvania II, L.P. (f/k/a Century-TCI California, L.P.), Century-TCI California Communications, LP, Century-TCI Holdings, LLC, Parnassos Communications, LP, Adelphia Consolidation, LLC, Parnassos Holdings, LLC, and Western NY Cablevision, LP, are herein referred to as the "ACC-Affiliated Counter-Defendants." On September 13, 2006, Rembrandt commenced an adversary proceeding (the "Adversary Proceeding") against the ACC-Affiliated Counter-Defendants (or, in the case of Adelphia Consolidation, LLC, Rembrandt commenced an adversary proceeding against predecessor entities Parnassos Distribution Company I LLC, Parnassos Distribution Company II LLC, and Century-TCI Distribution Company LLC) and filed an administrative proof of claim (the "Proof of Claim") against the ACC-Affiliated Counter-Defendants (or their predecessor entities) in each case in the Bankruptcy Court for the Southern District of New York in which the ACC-Affiliated Counter-Defendants' (or their predecessor entities') Chapter 11 cases were pending. In asserting the causes of action against the ACC-Affiliated Counter-Defendants that are set forth in the Counterclaim, the Counterclaim Plaintiffs intend to assert, and do assert, the same causes of action that Rembrandt previously asserted against the ACC-Affiliated Counter-Defendants (or their predecessor entities) in the Adversary Proceeding that are subject to the Proof of Claim and

seek the same recovery against the ACC-Affiliated Counter-Defendants' bankruptcy estates as was the subject of the Proof of Claim.

37. Counter-defendant Sharp Corporation is a corporation existing under the laws of Japan with a principal place of business in Osaka, Japan.

38. Counter-defendant Sharp Electronics Corporation is a corporation existing under the laws of New York with a principal place of business in Mahway, NJ. Sharp Electronics Corporation is a wholly-owned subsidiary of Sharp Corporation. Sharp Corporation and Sharp Electronics Corporation will be collectively referred to as "Sharp."

### **JURISDICTION AND VENUE**

39. This is an action for patent infringement, arising under the patent laws of the United States, 35 U.S.C. § 1, *et seq.*

40. Subject matter jurisdiction is proper in this court under 28 U.S.C. §§ 1331 and 1338(a).

41. This Court has personal jurisdiction over Plaintiffs/Counter-Defendants because they have submitted to the jurisdiction of this Court by filing the instant action; in addition, the Court has personal jurisdiction over Plaintiffs/Counter-Defendants because they have committed acts of patent infringement in this judicial district, are Delaware entities, and/or have other sufficient contacts with Delaware.

42. This Court has personal jurisdiction over MSO Counter-Defendants and Sharp because they either have previously availed themselves of the Court's jurisdiction, are Delaware entities, have property, offices, or personnel in Delaware, have committed acts of patent infringement in this judicial district, regularly transact business in Delaware, and/or have other sufficient contacts with Delaware.



43. Venue is proper in this judicial district under 28 U.S.C. §§ 1391(b), (c), and 1400(b).

**COUNT I**  
**INFRINGEMENT OF U.S. PATENT NO. 4,937,819**

44. Rembrandt realleges and incorporates herein by reference the allegations stated in paragraphs 1-43 of this Counterclaim.

45. Rembrandt is the owner of all right, title, and interest, including the right to sue, enforce, and recover damages for all infringements, of U.S. Patent No. 4,937,819, entitled “Time Orthogonal Multiple Virtual DCE Device for Use in Analog and Digital Networks” (the “’819 patent”) (Exhibit A to Plaintiff/Counter-Defendants’ Complaint).

46. The ‘819 patent was duly and legally issued by the United States Patent and Trademark Office on June 26, 1990.

47. Plaintiffs/Counter-Defendants are manufacturers of cable equipment, which equipment is sold to MSOs, including MSO Counter-Defendants, which, in turn, sell and/or lease some of that equipment and, additionally, use such equipment, throughout the United States in the operation of their cable networks.

48. Upon information and belief, Plaintiffs/Counter-Defendants have indirectly infringed, and are continuing to indirectly infringe, the ‘819 patent by practicing or causing others to practice (by inducement and/or contributorily) the inventions claimed in the ‘819 patent, in this district or otherwise within the United States. For example, upon information and belief, Plaintiffs/Counter-Defendants have indirectly infringed and continue to indirectly infringe the ‘819 patent by their manufacture and sale of cable equipment to cable MSOs for inclusion

into the MSOs' cable networks for the specific provision of high speed internet, cable broadband, and/or other services.

49. Upon information and belief, MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, have directly infringed, and are continuing to directly infringe, the '819 patent by practicing the inventions claimed in the '819 patent, in this district or otherwise within the United States. For example, upon information and belief, MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, have directly infringed and continue to directly infringe the '819 patent by including Plaintiff/Counter-Defendants' cable equipment in MSO Counter-Defendant's cable networks for the specific provision of high speed internet, cable broadband, and/or other services.

50. Upon information and belief, Plaintiffs/Counter-Defendants and MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, will continue to infringe the '819 patent unless enjoined by this Court. Upon information and belief, such infringement has been, and will continue to be, willful, making this an exceptional case and entitling Rembrandt to increased damages and reasonable attorneys' fees pursuant to 35 U.S.C. §§ 284 and 285.

**COUNT II**  
**INFRINGEMENT OF U.S. PATENT NO. 5,008,903**

51. Rembrandt realleges and incorporates herein by reference the allegations stated in paragraphs 1-50 of this Counterclaim.

52. Rembrandt is the owner of all right, title, and interest, including the right to sue, enforce, and recover damages for all infringements, of U.S. Patent No. 5,008,903, entitled "Adaptive Transmit Pre-Emphasis for Digital Modem Computed from Noise Spectrum" (the "903 patent") (Exhibit B to Plaintiff/Counter-Defendants' Complaint).

53. The '903 patent was duly and legally issued by the United States Patent and Trademark Office on April 16, 1991.

54. Plaintiffs/Counter-Defendants are manufacturers of cable equipment, which equipment is sold to MSOs, including MSO Counter-Defendants, which, in turn, sell and/or lease some of that equipment and, additionally, use such equipment, throughout the United States in the operation of their cable networks.

55. Upon information and belief, Plaintiffs/Counter-Defendants have indirectly infringed, and are continuing to indirectly infringe, the '903 patent by practicing or causing others to practice (by inducement and/or contributorily) the inventions claimed in the '903 patent, in this district or otherwise within the United States. For example, upon information and belief, Plaintiffs/Counter-Defendants have infringed and continue to infringe the '903 patent by their manufacture and sale of cable equipment to MSOs for inclusion into the MSOs' cable networks for the specific provision of high speed internet, cable broadband, and/or other services.

56. Upon information and belief, MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, have directly infringed, and are continuing to directly infringe, the '903 patent by practicing the inventions claimed in the '903 patent, in this district or otherwise within the United States. For example, upon information and belief, MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, have directly infringed and continue to directly infringe the '903 patent by including Plaintiff/Counter-Defendants' cable equipment in MSO Counter-Defendant cable networks for the specific provision of high speed internet, cable broadband, and/or other services.

57. Upon information and belief, Plaintiffs/Counter-Defendants and MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, will continue to infringe the '903 patent unless enjoined by this Court. Upon information and belief, such infringement has been, and will continue to be, willful, making this an exceptional case and entitling Rembrandt to increased damages and reasonable attorneys' fees pursuant to 35 U.S.C. §§ 284 and 285.

**COUNT III**  
**INFRINGEMENT OF U.S. PATENT NO. 5,710,761**

58. Rembrandt and Remstream reallege and incorporate herein by reference the allegations stated in paragraphs 1-57 of this Counterclaim.

59. Rembrandt is the owner, and Remstream is the exclusive licensee, of U.S. Patent No. 5,701,761, entitled "Error Control Negotiation Based on Modulation" (the "'761 patent") (Exhibit C to Plaintiff/Counter-Defendants' Complaint).

60. The '761 patent was duly and legally issued by the United States Patent and Trademark Office on January 20, 1998.

61. Plaintiffs/Counter-Defendants are manufacturers of cable equipment, which equipment is sold to MSOs, including MSO Counter-Defendants, which, in turn, sell and/or lease some of that equipment throughout the United States.

62. Plaintiffs/Counter-Defendants have directly and indirectly infringed, and are continuing to directly and indirectly infringe, the '761 patent by practicing or causing others to practice (by inducement and/or contributorily) the inventions claimed in the '761 patent, in this district or otherwise within the United States.

63. Upon information and belief, MSO Counter-Defendants have directly infringed, and/or are continuing to directly infringe, the '761 patent by practicing the inventions claimed in the '761 patent, in this district or otherwise within the United States.

64. Upon information and belief, Plaintiffs/Counter-Defendants and MSO Counter-Defendants (excepting ACC-Affiliated Counter-Defendants) will continue to infringe the '761 patent unless enjoined by this Court.

65. Upon information and belief, the infringement by Plaintiffs/Counter-Defendants and MSO Counter-Defendants has been, and/or will continue to be, willful, making this an exceptional case and entitling Counter-Plaintiffs to increased damages and reasonable attorneys' fees pursuant to 35 U.S.C. §§ 284 and 285.

**COUNT IV**  
**INFRINGEMENT OF U.S. PATENT NO. 5,719,858**

66. Rembrandt realleges and incorporates herein by reference the allegations stated in paragraphs 1-65 of this Counterclaim.

67. Rembrandt is the owner of all right, title, and interest, including the right to sue, enforce, and recover damages for all infringements, of U.S. Patent No. 5,719,858, entitled "Time-Division Multiple-Access Method for Packet Transmission on Shared Synchronous Serial Buses" (the "'858 patent") (Exhibit D to Plaintiff/Counter-Defendants' Complaint).

68. The '858 patent was duly and legally issued by the United States Patent and Trademark Office on February 17, 1998.

69. Plaintiffs/Counter-Defendants are manufacturers of cable equipment which equipment is sold to MSOs, including MSO Counter-Defendants, which, in turn, sell and/or lease

some of that equipment and, additionally, use such equipment, throughout the United States in the operation of their cable networks.

70. On information and belief, Plaintiffs/Counter-Defendants have indirectly infringed, and are continuing to indirectly infringe, the '858 patent by practicing or causing others to practice (by inducement and/or contributorily) the inventions claimed in the '858 patent, in this district or otherwise within the United States. For example, upon information and belief, Plaintiffs/Counter-Defendants have infringed and continue to infringe the '858 patent by their manufacture and sale of cable equipment to MSOs for inclusion into the MSOs' cable networks for the specific provision of high speed internet, cable broadband, and/or other services.

71. Upon information and belief, MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, have directly infringed, and are continuing to directly infringe, the '858 patent by practicing the inventions claimed in the '858 patent, in this district or otherwise within the United States. For example, upon information and belief, MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, have directly infringed and continue to directly infringe the '858 patent by including Plaintiff/Counter-Defendants' cable equipment in MSO Counter-Defendants' cable networks for the specific provision of high speed internet, cable broadband, and/or other services.

72. Upon information and belief, Plaintiffs/Counter-Defendants and MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, will continue to infringe the '858 patent unless enjoined by this Court. Upon information and belief, such infringement has been, and will continue to be, willful, making this an exceptional case and entitling Rembrandt to increased damages and reasonable attorneys' fees pursuant to 35 U.S.C. §§ 284 and 285.



**COUNT V**  
**INFRINGEMENT OF U.S. PATENT NO. 5,778,234**

73. Rembrandt and Remstream reallege and incorporate herein by reference the allegations stated in paragraphs 1-72 of this Counterclaim.

74. Rembrandt is the owner, and Remstream is the exclusive licensee, of U.S. Patent No. 5,778,234, entitled "Method for Downloading Programs" (the "'234 patent") (Exhibit E to Plaintiff/Counter-Defendants' Complaint).

75. The '234 patent was duly and legally issued by the United States Patent and Trademark Office on July 7, 1998.

76. Plaintiffs/Counter-Defendants are manufacturers of cable equipment which equipment is sold to MSOs, including MSO Counter-Defendants, which, in turn, sell and/or lease some of that equipment throughout the United States.

77. Plaintiffs/Counter-Defendants have directly and indirectly infringed, and are continuing to directly and indirectly infringe, the '234 patent by practicing or causing others to practice (by inducement and/or contributorily) the inventions claimed in the '234 patent, in this district or otherwise within the United States.

78. Upon information and belief, MSO Counter-Defendants have directly infringed, and/or are continuing to directly infringe, the '234 patent by practicing the inventions claimed in the '234 patent, in this district or otherwise within the United States.

79. Upon information and belief, Plaintiffs/Counter-Defendants and MSO Counter-Defendants (excepting ACC-Affiliated Counter-Defendants) will continue to infringe the '234 patent unless enjoined by this Court.

80. Upon information and belief, the infringement by Plaintiffs/Counter-Defendants and MSO Counter-Defendants has been, and/or will continue to be, willful, making this an

exceptional case and entitling Counter-Plaintiffs to increased damages and reasonable attorneys' fees pursuant to 35 U.S.C. §§ 284 and 285.

**COUNT VI**  
**INFRINGEMENT OF U.S. PATENT NO. 5,852,631**

81. Rembrandt realleges and incorporates herein by reference the allegations stated in paragraphs 1-80 of this Counterclaim.

82. Rembrandt is the owner of all right, title, and interest, including the right to sue, enforce, and recover damages for all infringements, of U.S. Patent No. 5,852,631, entitled "System and Method for Establishing Link Layer Parameters based on Physical Layer Modulation" (the "'631 patent") (Exhibit F to Plaintiff/Counter-Defendants' Complaint).

83. The '631 patent was duly and legally issued by the United States Patent and Trademark Office on December 22, 1998.

84. Plaintiffs/Counter-Defendants are manufacturers of cable equipment which equipment is sold to MSOs, including MSO Counter-Defendants, which, in turn, sell and/or lease some of that equipment and, additionally, use such equipment, throughout the United States in the operation of their cable networks.

85. On information and belief, Plaintiffs/Counter-Defendants have indirectly infringed, and are continuing to indirectly infringe, the '631 patent by practicing or causing others to practice (by inducement and/or contributorily) the inventions claimed in the '631 patent, in this district or otherwise within the United States. For example, on information and belief, Plaintiffs/Counter-Defendants have infringed and continue to infringe the '631 patent by their manufacture and sale of cable equipment to MSOs for inclusion into the MSOs' cable

networks for the specific provision of high speed internet, cable broadband, and/or other services.

86. Upon information and belief, MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, have directly infringed, and are continuing to directly infringe, the '631 patent by practicing the inventions claimed in the '631 patent, in this district or otherwise within the United States. For example, upon information and belief, MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, have directly infringed and continue to directly infringe the '631 patent by including Plaintiff/Counter-Defendants' cable equipment in MSO Counter-Defendants' cable networks for the specific provision of high speed internet, cable broadband, and/or other services.

87. Upon information and belief, Plaintiffs/Counter-Defendants and MSO Counter-Defendants, excepting ACC-Affiliated Counter-Defendants, will continue to infringe the '631 patent unless enjoined by this Court. Upon information and belief, such infringement has been, and will continue to be, willful, making this an exceptional case and entitling Counter-Plaintiffs to increased damages and reasonable attorneys' fees pursuant to 35 U.S.C. §§ 284 and 285.

**COUNT VII**  
**INFRINGEMENT OF U.S. PATENT NO. 6,131,159**

88. Rembrandt and Remstream reallege and incorporate herein by reference the allegations stated in paragraphs 1-87 of this Counterclaim.

89. Rembrandt is the owner, and Remstream is the exclusive licensee, of U.S. Patent No. 6,131,159, entitled "System for Downloading Programs" (the "'159 patent") (Exhibit G to Plaintiff/Counter-Defendants' Complaint).

90. The '159 patent was duly and legally issued by the United States Patent and Trademark Office on October 10, 2000.

91. Plaintiffs/Counter-Defendants are manufacturers of cable equipment which equipment is sold to MSOs, including MSO Counter-Defendants, which, in turn, sell and/or lease some of that equipment throughout the United States.

92. Plaintiffs/Counter-Defendants have directly and indirectly infringed, and are continuing to directly and indirectly infringe, the '159 patent by practicing or causing others to practice (by inducement and/or contributorily) the inventions claimed in the '159 patent, in this district or otherwise within the United States.

93. Upon information and belief, MSO Counter-Defendants have directly infringed, and/or are continuing to directly infringe, the '159 patent by practicing the inventions claimed in the '159 patent, in this district or otherwise within the United States.

94. Upon information and belief, Plaintiffs/Counter-Defendants and MSO Counter-Defendants (excepting ACC-Affiliated Counter-Defendants) will continue to infringe the '159 patent unless enjoined by this Court.

95. Upon information and belief, the infringement by Plaintiffs/Counter-Defendants and MSO Counter-Defendants has been, and/or will continue to be, willful, making this an exceptional case and entitling Counter-Plaintiffs to increased damages and reasonable attorneys' fees pursuant to 35 U.S.C. §§ 284 and 285.

**COUNT VIII**  
**INFRINGEMENT OF U.S. PATENT NO. 6,950,444**

96. Rembrandt and Remstream reallege and incorporate herein by reference the allegations stated in paragraphs 1-95 of this Counterclaim.

97. Rembrandt is the owner, and Remstream is the exclusive licensee , of U.S. Patent No. 6,950,444, entitled “System and Method for a Robust Preamble and Transmission Delimiting in a Switched-Carrier Transceiver (the “‘444 patent”) (Exhibit H to Plaintiff/Counter-Defendants’ Complaint).

98. The ‘444 patent was duly and legally issued by the United States Patent and Trademark Office on September 27, 2005.

99. Plaintiffs/Counter-Defendants are manufacturers of cable equipment which equipment is sold to MSOs, including MSO Counter-Defendants, which, in turn, sell and/or lease some of that equipment throughout the United States.

100. Plaintiffs/Counter-Defendants have directly and indirectly infringed, and are continuing to directly and indirectly infringe, the ‘444 patent by practicing or causing others to practice (by inducement and/or contributorily) the inventions claimed in the ‘444 patent, in this district or otherwise within the United States.

101. Upon information and belief, MSO Counter-Defendants have directly infringed, and/or are continuing to directly infringe, the ‘444 patent by practicing the inventions claimed in the ‘444 patent, in this district or otherwise within the United States.

102. Upon information and belief, Plaintiffs/Counter-Defendants and MSO Counter-Defendants (excepting ACC-Affiliated Counter-Defendants) will continue to infringe the ‘444 patent unless enjoined by this Court.

103. Upon information and belief, the infringement by Plaintiffs/Counter-Defendants and MSO Counter-Defendants the infringement has been, and/or will continue to be, willful, making this an exceptional case and entitling Counter-Plaintiffs to increased damages and reasonable attorneys’ fees pursuant to 35 U.S.C. §§ 284 and 285.

**COUNT IX**  
**INFRINGEMENT OF U.S. PATENT NO. 5,243,627**

104. Rembrandt realleges and incorporates herein by reference the allegations stated in paragraphs 1-103 of this Counterclaim.

105. Rembrandt is the owner of all right, title and interest of U.S. Patent No. 5,243,627, entitled "Signal Point Interleaving Technique" ("the '627 patent") (Exhibit A hereto).

106. The '627 patent was duly and legally issued by the United States Patent and Trademark Office on September 7, 1993.

107. Upon information and belief, Comcast Cable Communications Holdings, Inc., Comcast Corporation, Comcast Cable Communications, LLC, Century-TCI California Communications, LP, Comcast of Florida/Pennsylvania, L.P. (f/k/a Parnassos, LP), Comcast of Pennsylvania II, L.P., Parnassos Communications LP, Cablevision Systems Corporation, CSC Holdings, Inc., Time Warner Cable, Inc., Time Warner Cable LLC, Time Warner NY Cable LLC, Time Warner Entertainment Company, LP, Time Warner Entertainment-Advance/Newhouse Partnership, CoxCom, Inc., Charter Communications, Inc., Charter Communications Operating, LCC, Sharp Corporation, and Sharp Electronics Corporation (the "627 Infringers") have directly or indirectly infringed, and are continuing to directly or indirectly infringe, the '627 patent by practicing or causing others to practice (by inducement and/or contributorily) the inventions claimed in the '627 patent, in this district or otherwise within the United States.

108. Upon information and belief, the '627 Infringers will continue to infringe the '627 patent unless enjoined by this Court. Upon information and belief, such infringement has been, and will continue to be, willful, making this an exceptional case and entitling Rembrandt to increased damages and reasonable attorneys' fees pursuant to 35 U.S.C. §§ 284 and 285.



109. Rembrandt and Remstream demand a jury trial for all Counts set forth above to which they are a party and wherein such issues are jury triable.

**PRAYER FOR RELIEF**

WHEREFORE, Rembrandt and Remstream pray that they have judgment against Plaintiffs/Counter-Defendants, MSO Counter-Defendants, and '627 Infringers for the following:

1. A judgment that Plaintiffs/Counter-Defendants, MSO Counter-Defendants, and '627 Infringers have infringed the patents-in-suit as alleged in the Counterclaims;
2. A permanent injunction enjoining and restraining Plaintiffs/Counter-Defendants, MSO Counter-Defendants (excepting ACC-Affiliated Counter-Defendants), and the '627 Infringers and their agents, servants, employees, affiliates, divisions, and subsidiaries, and those in association with them, from making, using, testing, offering to sell, selling, leasing, and importing into the United States any product, or using, offering to sell, offering to lease, selling, or leasing any service, that falls within the scope of any claim of a patent-in-suit asserted against a party as alleged in the Counterclaims;
3. An award of damages, and pre-judgment and post-judgment interest;
4. An award of increased damages pursuant to 35 U.S.C. § 284;
5. A judgment that this case is exceptional under 35 U.S.C. § 285 and requiring Plaintiffs/Counter-Defendants, MSO Counter-Defendants and/or '627 Infringers to pay the costs of this action, including all disbursements and attorneys' fees; and
6. Such other and further relief, at law or in equity, to which counter-plaintiffs Rembrandt and/or Remstream are justly entitled.

Dated: May 2, 2008

/s/ Collins J. Seitz, Jr.

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Rembrandt Technologies, LLC d/b/a Remstream

606981

**CERTIFICATE OF SERVICE**

I, Collins J. Seitz, Jr., hereby certify that on the 5<sup>th</sup> day of May, 2008, a true copy of the foregoing document was electronically filed with the Clerk of the Court using CM/ECF which will send notification of such filing to the following and the document is available for viewing and downloading from CM/ECF:

**BY E-MAIL**

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# EXHIBIT

# A





US005243627A

## United States Patent [19]

[11] Patent Number: 5,243,627

Betts et al.

[45] **Date of Patent:** Sep. 7, 1993

[54] SIGNAL POINT INTERLEAVING  
TECHNIQUE

[75] Inventors: William L. Betts, St. Petersburg;  
Edward S. Zuranski, Largo, both of  
Fla.

[73] Assignee: AT&T Bell Laboratories, Murray Hill, N.J.

[21] Appl. No.: 748,594

[22] Filed: Aug. 22, 1991

[51] Int. Cl.<sup>5</sup> ..... H04L 5/12

[52] U.S. Cl. .... 375/39; 375/60;  
375/99; 371/43

[58] Field of Search ..... 375/39, 58, 60, 99;  
371/43, 37.5, 2.1, 45; 341/81

## [56]

### References Cited

## U.S. PATENT DOCUMENTS

3,988,677	10/1976	Fletcher et al. ....	371/45 X
4,677,624	6/1987	Betts et al. ....	375/39
4,945,549	7/1990	Simon et al. ....	375/53
5,029,185	7/1991	Wei .....	375/39 X

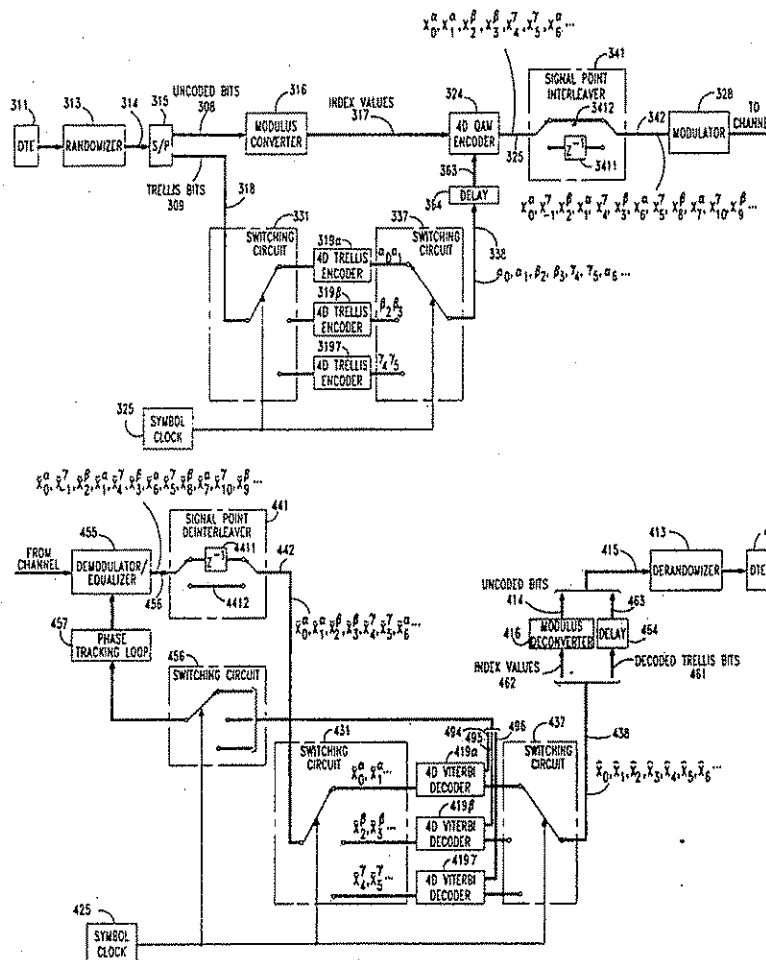
*Primary Examiner*—Curtis Kuntz  
*Assistant Examiner*—Tesfaldet Bocure  
*Attorney, Agent, or Firm*—Ronald D. Slusky; Gerard A. deBlasi

## [57]

## ABSTRACT

Viterbi decoder performance in a data communication system using  $2N$ -dimensional channel symbols  $N > 1$  can be further enhanced by an interleaving technique which uses a distributed trellis encoder in combination with a signal point interleaver.

**24 Claims, 4 Drawing Sheets**



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FIG. 1

PRIOR ART

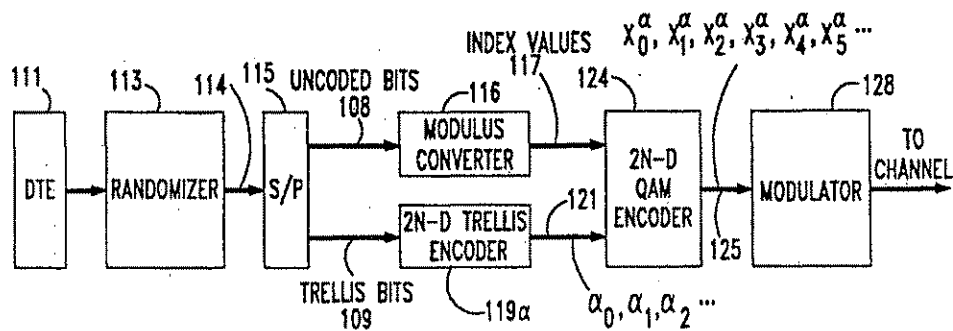
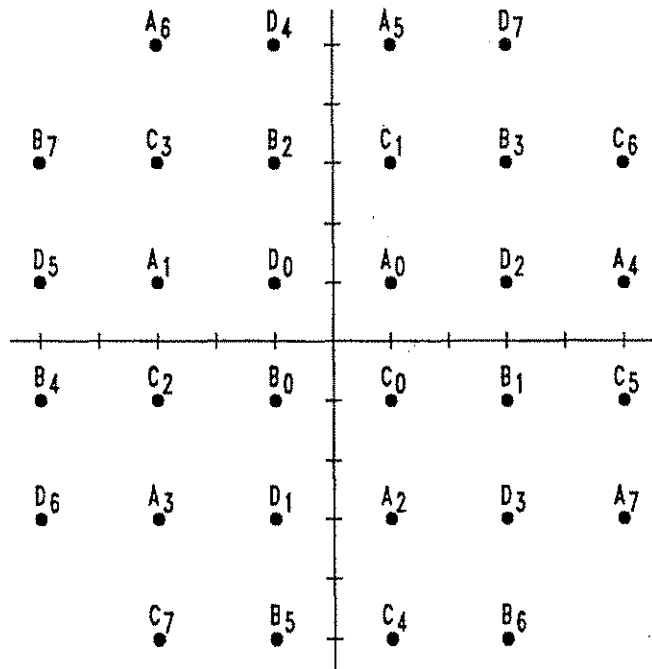


FIG. 2



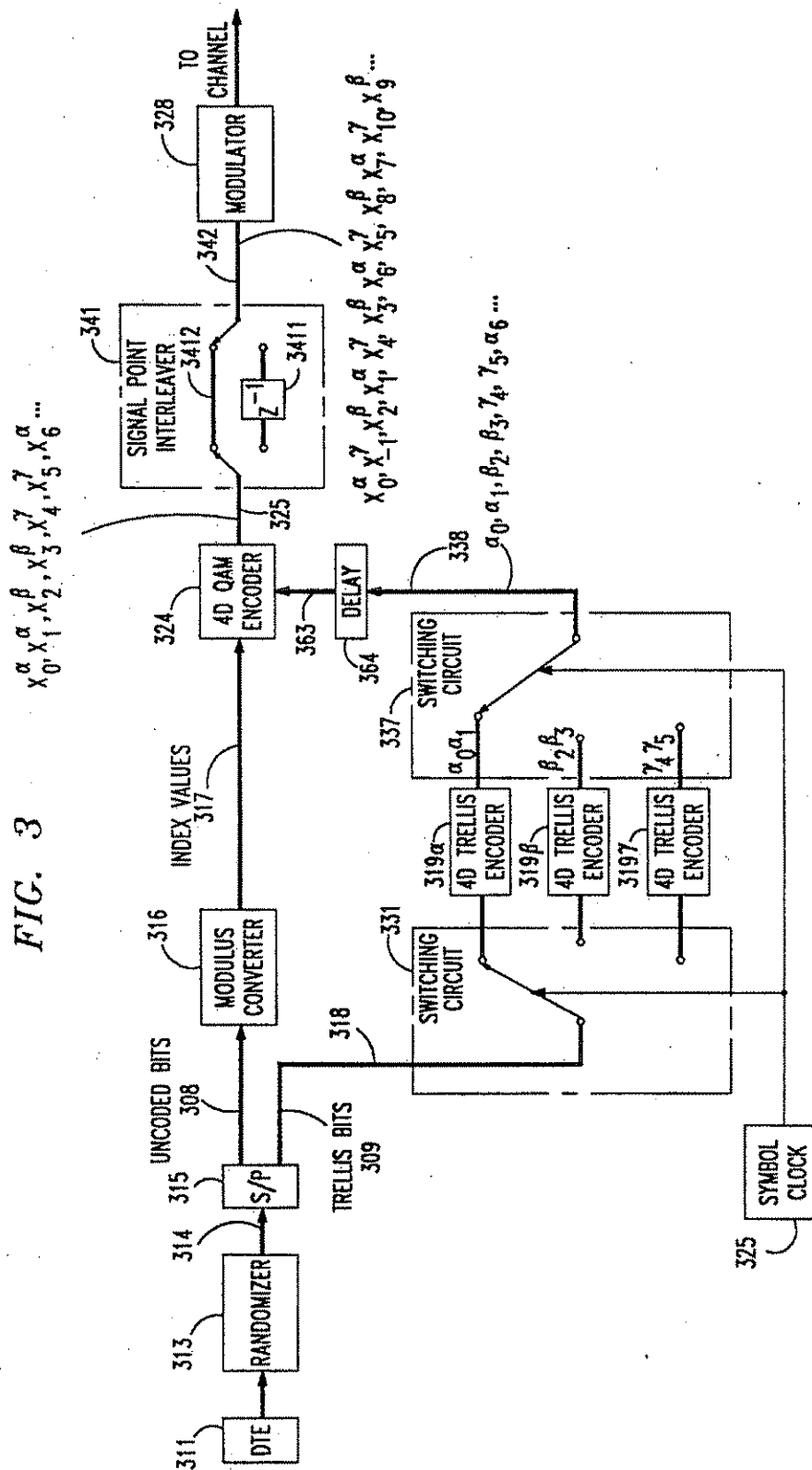
U.S. Patent

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FIG. 3



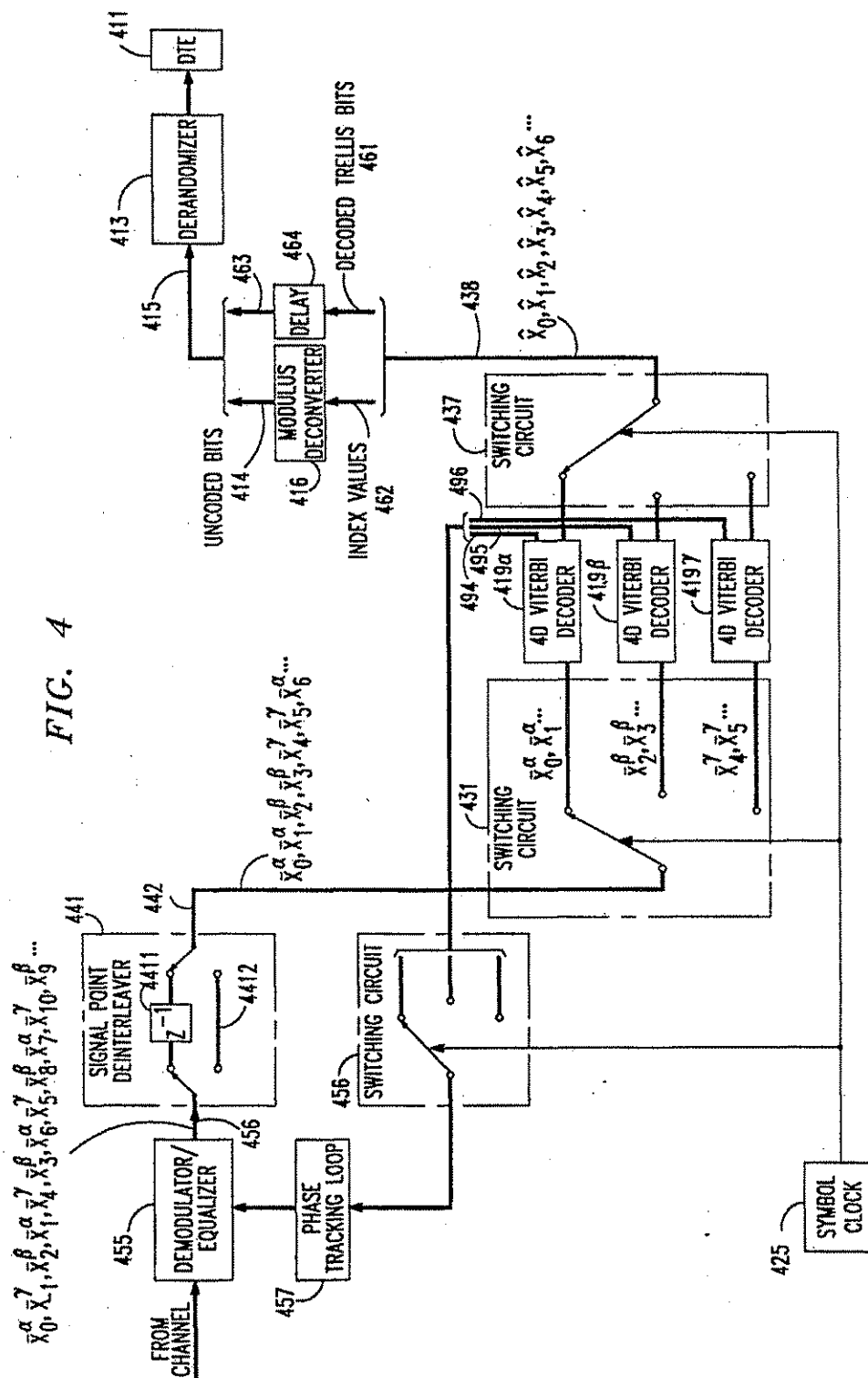
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FIG. 4



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FIG. 5

		4D SYMBOL	4D SYMBOL	4D SYMBOL	4D SYMBOL	4D SYMBOL	4D SYMBOL					
I	NOT INTERLEAVED ONE TRELLIS STAGE	$x_0^\alpha$	$x_1^\alpha$	$x_2^\alpha$	$x_3^\alpha$	$x_4^\alpha$	$x_5^\alpha$	$x_6^\alpha$	$x_7^\alpha$	$x_8^\alpha$	$x_9^\alpha$	$x_{10}^\alpha \dots$
II	NOT INTERLEAVED THREE TRELLIS STAGES	$x_0^\alpha$	$x_1^\alpha$	$x_2^\beta$	$x_3^\beta$	$x_4^\gamma$	$x_5^\gamma$	$x_6^\alpha$	$x_7^\alpha$	$x_8^\beta$	$x_9^\beta$	$x_{10}^\gamma \dots$
III	INTERLEAVED ONE TRELLIS STAGE	$x_0^\alpha$	$x_{-1}^\alpha$	$x_2^\alpha$	$x_1^\alpha$	$x_4^\alpha$	$x_3^\alpha$	$x_6^\alpha$	$x_5^\alpha$	$x_8^\alpha$	$x_7^\alpha$	$x_{10}^\alpha \dots$
IV	INTERLEAVED TWO TRELLIS STAGES	$x_0^\alpha$	$x_{-1}^\beta$	$x_2^\beta$	$x_1^\alpha$	$x_4^\alpha$	$x_3^\beta$	$x_6^\beta$	$x_5^\alpha$	$x_8^\alpha$	$x_7^\beta$	$x_{10}^\beta \dots$
V	INTERLEAVED THREE TRELLIS STAGES	$x_0^\alpha$	$x_{-1}^\gamma$	$x_2^\beta$	$x_1^\alpha$	$x_4^\gamma$	$x_3^\beta$	$x_6^\alpha$	$x_5^\gamma$	$x_8^\beta$	$x_7^\alpha$	$x_{10}^\gamma \dots$

FIG. 6

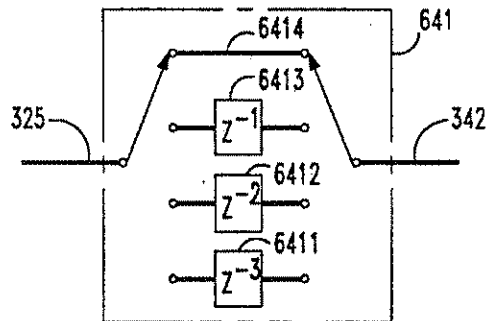
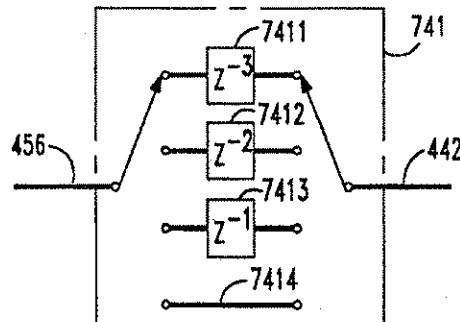


FIG. 7



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## SIGNAL POINT INTERLEAVING TECHNIQUE

## BACKGROUND OF THE INVENTION

The present invention relates to the transmission of digital data over band-limited channels.

Over the years, the requirements of modern-day digital data transmission over band-limited channels—such as voiceband telephone channels—have resulted in a push for higher and higher bit rates. This push has led to the development and introduction of such innovations as adaptive equalization, multi-dimensional signal constellations, echo cancellation (for two-wire applications), and trellis coding. Today, the data rates achieved using these and other techniques are beginning to approach the theoretical limits of the channel.

It has been found that various channel impairments, whose effects on the achievable bit rate were relatively minor compared to, say, additive white Gaussian noise and linear distortion, have now become of greater concern. These include such impairments as nonlinear distortion and residual (i.e., uncompensated-for) phase jitter. Such impairments are particularly irksome in systems which use trellis coding. Indeed, it has been found that the theoretical improvement in Gaussian noise immunity promised by at least some trellis codes is not realized in real-world applications where these impairments are manifest. The principal reason this is so appears to be that the noise components introduced into the received signal samples are such as to worsen the effectiveness of the Viterbi decoder used in the receiver to recover the transmitted data.

U.S. Pat. No. 4,677,625, issued Jun. 30, 1987 to Betts et al, teaches a method and arrangement in which, through the use of a distributed trellis encoder/Viterbi decoder, the effects of many of these impairments can be reduced. The invention in the Betts et al patent recognizes that a part of the reason that the performance of the Viterbi decoder is degraded by these impairments is the fact that the noise components of channel symbols which closely follow one another in the transmission channel are highly correlated for many types of impairments. And it is that correlation which worsens the effect that these impairments have on the Viterbi decoder. Among the impairments whose noise is correlated in this way are impulse noise, phase "hits" and gain "hits." All of these typically extend over a number of adjacent channel symbols in the channel, and thus all result in channel symbol noise components which are highly correlated. The well-known noise enhancement characteristics of linear equalizers also induce correlated noise in adjacent channel symbols, as does uncompensated-for phase jitter. Also, the occurrence of one of the relatively high power points of the signal constellation can, in pulse code modulation (PCM) systems, for example, give rise to noise on adjacent channel symbols which, again, is correlated.

The Betts et al patent addresses this issue by distributing the outgoing data to a plurality of trellis encoders in round-robin fashion and interleaving the trellis encoder outputs on the transmission channel. In the receiver, the stream of received interleaved channel symbols is correspondingly distributed to a plurality of trellis decoders. Since the successive pairs of channel symbols applied to a particular trellis decoder are separated from one another as they traverse the channel, the correlation of the noise components of these channel symbol

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pairs is reduced from what it would have otherwise been.

## SUMMARY OF THE INVENTION

In accordance with the present invention, it has been realized that the Viterbi decoder performance in a data communication system using  $2N$ -dimensional channel symbols can be further enhanced by an interleaving technique which uses, in combination, a) the aforementioned distributed trellis encoder/Viterbi decoder technique and b) a signal point interleaving technique which causes the constituent signal points of the channel symbols to be non-adjacent as they traverse the channel.

In preferred embodiments of the invention, the interleaving is carried out in such a way that every  $N^{\text{th}}$  signal point in the signal point stream traversing the channel is the  $N^{\text{th}}$  signal point of a respective one of the channel symbols. This criterion enhances the accuracy with which the phase tracking loop in the receiver performs its function.

Also in preferred embodiments, we have found that the use of three parallel trellis encoders in conjunction with a signal point interleaving regime in which the signal points of each channel symbol are separated from one another by three signaling intervals (bauds) provides an optimum or near-optimum tradeoff between signal point/channel symbol separation and the decoding delay that is caused by the interleaving.

## BRIEF DESCRIPTION OF THE DRAWING

In the drawing,

FIG. 1 is a block diagram of the transmitter section of a prior art modem;

FIG. 2 is shows a signal constellation used by the transmitter of FIG. 1;

FIG. 3 is a block diagram of the transmitter section of a modem employing four-dimensional channel symbols and embodying the principles of the invention;

FIG. 4 is a block diagram of the receiver section of a modem embodying the principles of the invention which processes the received four-dimensional channel symbols generated by the transmitter of FIG. 3;

FIG. 5 is a signal point timing/sequencing chart helpful in explaining the principles of the present invention;

FIG. 6 is a signal point interleaver which can be used in the transmitter of FIG. 3 to interleave the signal points of eight-dimensional channel symbols; and

FIG. 7 is a signal point deinterleaver which can be used in the receiver of FIG. 4 to deinterleave the signal points of eight-dimensional channel symbols.

## DETAILED DESCRIPTION

FIG. 1 depicts the transmitter section of a prior art modem employing a  $2N$ -dimensional signaling scheme,  $N \geq 1$ . The modem receives input information in the form of a serial bit stream from data terminal equipment (DTE) 111—illustratively a host computer. That bit stream is then scrambled, or randomized, by randomizer 113 whose output bits are provided in serial form to serial-to-parallel (S/P) converter 115.

Serial-to-parallel converter 115, in turn, provides, during each of a succession of symbol intervals (comprised of  $N$  baud intervals), some predetermined number of parallel bits on lead 109 and some number of parallel bits on lead 108. (It will be appreciated that whenever bits are provided in parallel in the modem, separate leads are required to carry each of the bits.) The bits on lead 109 are applied to trellis encoder 119a,



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and are referred to as the "trellis bits." The bits on lead 108 are applied to modulus converter 116, and are referred to as the "uncoded bits."

To better understand how trellis encoder 119 $\alpha$  and modulus converter 116 work, reference is made to FIG. 2, which shows the two-dimensional signal constellation that forms the basis of the 2N-dimensional signaling scheme illustratively used by the modem. This constellation is comprised of 32 signal points, which are divided into four subsets, A through D, each comprised of eight signal points. The eight points of subset A are explicitly labeled as A<sub>0</sub> through A<sub>7</sub>. It may be noted that subsets C, B and D can be arrived at by clockwise rotation of subset A by 90, 180 and 270 degrees, respectively. (Conventional differential encoding circuitry within trellis encoder 119 $\alpha$  exploits this symmetry.) For reference, a single signal point of each of those subsets is also shown on FIG. 2.

Consider, first, the case of N=1, i.e., a two-dimensional signaling scheme. In this case, one trellis bit on lead 109 would be expanded to two bits by trellis encoder 119 $\alpha$  on lead 121. The four possible values of those three bits 00, 01, 10, and 11 identify subsets A, B, C and D, respectively. The successive 2-bit words on lead 121 are represented as  $a_n$ ,  $n=0, 1, 2, \dots$ , where n is an index that advances at the baud rate. At the same time, three parallel bits would be provided on lead 108. These are converted by modulus converter 116 into an index having a value within the range (decimal) 0 to 7. The index value, represented in binary form on lead 117, selects a particular signal point from the subset identified on lead 121. Thus if lead 121 carries the two bits 00 while lead 117 carries the three bits 001, then signal point A<sub>1</sub> of the FIG. 2 constellation has been selected. The words on leads 117 and 121 are applied to QAM encoder 124 which generates, on lead 125, values representing the I (in-phase) and Q (quadrature-phase) components of signal point A<sub>1</sub>. The signal point generated on lead 125 in the n<sup>th</sup> baud interval is denoted X<sub>n</sub> <sup>$\alpha$</sup> , which is passed on to modulator 128 to generate a pass-band line signal which is applied to the communication channel. The superscript,  $\alpha$ , indicates that the trellis encoder that was used to identify the subset for any particular signal point was trellis encoder 119 $\alpha$ . That is, of course, a trivial notation as far as FIG. 1 goes inasmuch as trellis encoder 119 $\alpha$  is the only trellis encoder in the modem. However, it is useful to introduce this notation because more than one trellis encoder stage is used in preferred embodiments of modems incorporating the principles of the present invention as shown in later FIGS.

In the case of N>1, the operation is similar. Now, however, the words on lead 109 are used by trellis encoder 119 $\alpha$  to sequentially identify on lead 121N subsets, while the words on lead 108 are used to generate N corresponding index values on lead 117. The N signal points identified in this way are the component signal points of a 2N-dimensional channel symbol, the first such symbol being comprised of the signal points X<sub>0</sub> <sup>$\alpha$</sup> ,  $\dots$ , X<sub>(N-1)</sub> <sup>$\alpha$</sup> . For example, a modem in which the transmitter of FIG. 1 could be used may be a 14,400 bit per second modem using four-dimensional coding (i.e., N=2) and a baud rate of 3200. In this case, nine bits from S/P converter 115 are used for each four-dimensional symbol. Specifically, three parallel bits on lead 109 are expanded into four bits on lead 121 to identify a pair of subsets while six bits on lead 108 are used to select particular signal points from those two subsets.

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Those two signal points are thereupon communicated over the channel by QAM encoder 124 and modulator 128 as described above.

Note that, implementationally, the 2N-dimensional channel symbol is generated by having the trellis encoder identify, interdependently, N subsets of the two-dimensional constellation of FIG. 2, then select a two-dimensional signal point from each of the subsets thus identified. The concatenation of the N two-dimensional signal points thus selected is the desired 2N-dimensional channel symbol. This process, however, can be understood as involving the direct selection of a 2N-dimensional channel symbol. Viewed in this context, the set of all possible combinations of N of the two-dimensional subsets identified by N successive trellis encoder outputs can be understood to be a set of 2N-dimensional subsets of a 2N-dimensional constellation, the latter being comprised of all possible combinations of N of the signal points of the two-dimensional constellation. A succession of N outputs from the trellis encoder identifies a particular one of the 2N-dimensional subsets and a succession of N outputs from the modulus converter selects a particular 2N-dimensional signal point from the identified 2N-dimensional subset.

Modulus converter 116 is illustratively of the type disclosed in co-pending, commonly-assigned U.S. patent application Ser. No. 588,658 filed Sep. 26, 1990 and allowed on May 21, 1991, hereby incorporated by reference. Modulus converter 116 provides the modem with the ability to support data transmission at various different bit rates. Assume, for example, that the rate at which bits are provided by DTE 111 decreases. The serial-to-parallel converter will continue to provide its outputs on leads 108 and 109 at the same baud rate as before. However, the upper limit of the range of index values that are provided by modulus converter 116 on lead 117 will be reduced, so that, effectively, each of the four subsets A through D, instead of having eight signal points, will have some smaller number. Conversely if the rate at which bits are provided by DTE 111 should increase over that originally assumed, the upper limit of the range of index values, and thus the number of parallel bits, that appear on lead 117 will be increased beyond eight and the constellation itself will be expanded to accommodate the larger number of signal points thus being selected. As an alternative to using a modulus converter, fractional bit rates can be supported using, for example, the technique disclosed in L. Wei, "Trellis-Coded Modulation with Multidimensional Constellations," *IEEE Trans. on Communication Theory*, Vol. IT-33, No. 4, July 1987, pp. 483-501.

Turning now to FIG. 3, the transmitter portion of a modem embodying the principles of the invention is shown. This embodiment illustratively uses the aforementioned four-dimensional, i.e., N=2, signaling scheme. Many of the components are similar to those shown in FIG. 1. Thus, in particular, the transmitter of FIG. 3—which receives its input information in the form of a stream of input bits from DTE 311—includes randomizer 313, which supplies its output, on lead 314, to S/P converter 315. The latter outputs uncoded bits to modulus converter 316. The transmitter further includes four-dimensional QAM encoder 324 and modulator 328. The trellis bits, on lead 309, are provided not to a standard single trellis encoder, but to a distributed trellis encoder comprised of three trellis encoder stages: trellis encoder stage 319 $\alpha$ , trellis encoder stage 319 $\beta$ , and trellis encoder stage 319 $\gamma$ .

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Such a distributed trellis encoder, which is described in the aforementioned Betts et al patent, generates a plurality of streams of trellis encoded channel symbols in response to respective portions of the input information. Specifically, a three-bit word on lead 309 is supplied to trellis encoder stage 319 $\alpha$ . The next three-bit word on lead 309 is supplied to trellis encoder stage 319 $\beta$ . The next three-bit word is supplied to trellis encoder stage 319 $\gamma$ , and then back to trellis encoder stage 319 $\alpha$ . This distribution of the trellis bits to the various trellis encoder stages is performed by switching circuit 331 operating under the control of symbol clock 325. The initial data word outputs of the trellis encoders are subset identifiers  $\alpha_0$  and  $\alpha_1$  for encoder stage 319 $\alpha$ ,  $\beta_2$  and  $\beta_3$  for encoder stage 319 $\beta$ , and  $\gamma_4$  and  $\gamma_5$  for encoder stage 319 $\gamma$ , followed by  $\alpha_6$  and  $\alpha_7$  for encoder stage 319 $\alpha$ , and so forth. These are supplied to four-dimensional QAM encoder 324 by switching circuit 337—also operating under the control of symbol clock 325—on lead 338 through a one-symbol delay 364 and lead 363, in order to compensate for a one-symbol delay caused by modulus converter 316. Thus, the stream of subset identifiers on lead 338 is  $\alpha_0, \alpha_1, \beta_2, \beta_3, \gamma_4, \gamma_5, \alpha_6, \dots$ . Using the notation introduced above, then, the output of encoder 324 on lead 325 is the stream of signal points  $X_0^\alpha, X_1^\alpha, X_2^\beta, X_3^\beta, X_4^\gamma, X_5^\gamma, X_6^\alpha, \dots$ , which is comprised of three interleaved streams of trellis encoded channel symbols, these streams being  $X_0^\alpha, X_1^\alpha, X_6^\alpha, X_7^\alpha, X_{12}^\alpha, \dots$ ;  $X_2^\beta, X_3^\beta, X_8^\beta, X_9^\beta, X_{14}^\beta, \dots$ ; and  $X_4^\gamma, X_5^\gamma, X_{10}^\gamma, X_{11}^\gamma, X_{16}^\gamma, \dots$ . These, in turn, are supplied, in accordance with the invention, to signal point interleaver 341 which applies alternate ones of the signal points applied thereto to lead 3412—which signal points appear immediately at the interleaver output on lead 342—and to one-symbol ( $Z^{-1}$ ) delay element 3411, which appear on lead 342 after being delayed therein by one symbol interval. The resulting interleaved stream of trellis encoded signal points is  $X_0^\alpha, X_{-1}^\gamma, X_2^\beta, X_1^\alpha, X_4^\gamma, X_3^\beta, X_6^\alpha, X_5^\gamma, X_8^\beta, X_7^\alpha, X_{10}^\gamma, X_9^\beta, \dots$  (the signal point  $X_{-1}^\gamma$  being, of course, the signal point applied to interleaver 341 just ahead of signal point  $X_0^\alpha$ ).

A discussion and explanation of how the interleaving just described is advantageous is set forth hereinbelow. In order to fully set the stage for that explanation, however, it will be first useful to consider the receiver section of a modem which receives the interleaved signal point stream.

Thus referring to FIG. 4, the line signal transmitted by the transmitter of FIG. 3 is received from the channel and applied to demodulator/equalizer 455 which, in conventional fashion—including an input from phase tracking loop 457—generates a stream of outputs on lead 456 representing the demodulator/equalizer's best approximation of the values of the I and Q components of the signal points of the transmitted interleaved signal point stream. These outputs are referred to herein as the "received signal points." (Due to distortion and other channel impairments that the demodulator/equalizer is not able to compensate for, the I and Q components of the received signal points, instead of having exact integer values, can have any value. Thus a transmitted signal point having coordinates (3, -5) may be output by the demodulator/equalizer as the received signal point (2.945, -5.001).) The stream of received signal points on lead 456 is denoted  $\bar{X}_0^\alpha, \bar{X}_{-1}^\gamma, \bar{X}_2^\beta, \bar{X}_1^\alpha, \bar{X}_4^\gamma, \bar{X}_3^\beta, \bar{X}_6^\alpha, \bar{X}_5^\gamma, \bar{X}_8^\beta, \bar{X}_7^\alpha, \bar{X}_{10}^\gamma, \bar{X}_9^\beta, \dots$ .

The successive received signal points are deinterleaved in signal point deinterleaver 441, which provides

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the opposite function to interleaver 341 in the transmitter. The output of deinterleaver 441 on lead 442 is thus  $\bar{X}_0^\alpha, \bar{X}_1^\alpha, \bar{X}_2^\beta, \bar{X}_3^\beta, \bar{X}_4^\gamma, \bar{X}_5^\gamma, \bar{X}_6^\alpha, \dots$ , etc. (Although not explicitly shown in the drawing, the same well-known techniques used in modems of this general kind to identify within the stream of received signal points the boundaries between successive symbols is used to synchronize the operation of signal point deinterleaver 441 to ensure that received signal points  $\bar{X}_0^\alpha, \bar{X}_2^\beta, \bar{X}_4^\gamma, \dots$  are applied to delay element 4411 while received signal points  $\bar{X}_1^\alpha, \bar{X}_3^\beta, \bar{X}_5^\gamma, \dots$  are applied to lead 4412.)

The received signal points on lead 442 are then distributed by switching circuit 431 under the control of symbol clock 425 to a distributed Viterbi decoder comprised of 4D Viterbi decoder stages 419 $\alpha$ , 419 $\beta$  and 419 $\gamma$ . Specifically, received signal points  $\bar{X}_0^\alpha$  and  $\bar{X}_1^\alpha$  are applied to decoder stage 419 $\alpha$ ; received signal points  $\bar{X}_2^\beta$  and  $\bar{X}_3^\beta$  are applied to decoder stage 419 $\beta$ ; and received signal points  $\bar{X}_4^\gamma$  and  $\bar{X}_5^\gamma$  are applied to decoder stage 419 $\gamma$ . The outputs of the three decoder stages are then combined into a serial stream on lead 438 by switching circuit 437, also operating under the control of symbol clock 425. Those outputs, representing decisions as to the values of the transmitted signal points, are denoted  $\hat{X}_0, \hat{X}_1, \hat{X}_2, \hat{X}_3, \hat{X}_4, \hat{X}_5, \hat{X}_6, \dots$ , the  $\alpha, \beta$  and  $\gamma$  superscripts no longer being needed.

In conventional fashion, the bits that represent each of the decisions on lead 438 can be divided into bits that represent a) the trellis bits that appeared on transmitter lead 309 and b) the index values that appeared on transmitter lead 317. Those two groups of bits are provided in the receiver on leads 461 and 462, respectively. The latter group of bits are deconverted by modulus deconverter 416 (also disclosed in the aforementioned '658 patent application) back to uncoded bit values on lead 414. The operation of the modulus deconverter imparts a one-symbol delay to the bits on lead 414. Accordingly, the bits on lead 461 are caused to be delayed by one symbol by delay element 464. The resulting combined bits on lead 415 thus represent the stream of bits that appeared at the output of randomizer 313 in the transmitter. These are derandomized in the receiver by derandomizer 413 and the resulting derandomized bit stream is applied to DTE 411 which may be, for example, a computer terminal.

Referring to FIG. 5, one can see the improvement that is achieved by the present invention.

Line I shows the stream of output signal points generated and launched into the channel using one stage of trellis encoding and no signal point interleaving. This is, of course, the prior art arrangement shown in FIG. 1. Line II shows the effect of providing a three-stage distributed trellis encoder but still no signal point interleaving. This is the arrangement shown in the aforementioned Betts et al patent. Note that the signal points of each channel symbol operated on by a particular trellis encoder stage are adjacent in the output signal point stream. For example, the second signal point of the symbol  $X_0^\alpha X_1^\alpha$ —namely signal point  $X_1^\alpha$ —is separated by five baud intervals from the first (closer) signal point of the symbol  $X_6^\alpha X_7^\alpha$ —namely signal point  $X_6^\alpha$ . As noted earlier, such separation is advantageous because the channel symbols which are processed one after the other in a particular Viterbi decoder stage have noise components which are not highly correlated.

Note, however, that the individual signal points of each channel symbol, e.g.,  $X_0^\alpha$  and  $X_1^\alpha$ , are adjacent to

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one another as they pass through the channel; and since all the signal points of a channel symbol must be processed serially in the same Viterbi decoder stage, this means that the Viterbi decoder must process adjacent signal points that have highly correlated noise components.

It is to this end that signal point interleaver 341 is included within the transmitter in accordance with the invention. Firstly, it may be noted from Line III that using the signal point interleaver without the distributed trellis encoder—an arrangement not depicted in the drawing—will, advantageously, cause the signal points from the same channel symbol to be non-adjacent. Moreover, there is further advantage in that a pair of channel symbols processed serially by Viterbi decoder stage 419 $\alpha$  traverses the channel separated by five baud intervals rather than three, thereby providing greater decorrelation of the noise components thereof. Compare, for example, the span of baud intervals occupied by signal points  $X_0^\alpha$  and  $X_1^\alpha$ ,  $X_2^\alpha$  and  $X_3^\alpha$  in Line I and the span of baud intervals occupied by the same signal points in Line III. Disadvantageously, however, the use of a single trellis encoding stage brings back the problem that the distributed trellis encoder solves, as described above. Thus, for example, although signal points  $X_0^\alpha$  and  $X_1^\alpha$ , which are from the same channel symbol, are separated from one another when traversing the channel, we find that, disadvantageously, signal points  $X_2^\alpha$  and  $X_1^\alpha$ , which are signal points from two different channel symbols which will be processed serially by the Viterbi decoder, traverse the channel adjacent to one another.

Line IV shows that using the signal point interleaver with a two-stage trellis encoder—also an arrangement not depicted in the drawing—provides some improvement. Firstly, it may be noted that, as in Line III, signal points from the same channel symbol remain separated by three baud intervals. Additionally, pairs of channel symbols processed sequentially by a given Viterbi decoder stage—such as the channel symbols comprised of signal points  $X_0^\alpha$  and  $X_1^\alpha$ ,  $X_4^\alpha$  and  $X_5^\alpha$ —are still non-adjacent and, indeed, are now separated by seven baud intervals, which is even greater than the separation of five baud intervals provided in Line III. Moreover, certain signal points that traverse the channel adjacent to one another and which are from channel symbols which would have been decoded sequentially in the one-trellis-encoding-stage case are, in the two-trellis-encoding-stage case of Line IV, processed by different Viterbi decoding stages. Signal points  $X_2^\beta$  and  $X_1^\alpha$  are such a pair of signal points. Note, however, that, disadvantageously, signal points  $X_1^\alpha$  and  $X_4^\alpha$  traverse the channel serially, and are from channel symbols which are serially processed by the “ $\alpha$ ” Viterbi decoder stage.

Referring, however, to Line V, which depicts the stream of signal points output by the transmitter of FIG. 3, it will be seen that, in accordance with the invention, there is still a non-adjacency—indeed, a separation of at least three baud intervals—between a) the signal points which belong to any particular channel symbol (and which, therefore, are processed serially by a particular Viterbi decoder stage) and b) the signal points which belong to channel symbols which are processed serially by a Viterbi decoder stage. Thus, for example, signal points  $X_1^\alpha$  and  $X_4^\gamma$  are now processed by different Viterbi decoder stages. Moreover, pairs of channel symbols processed sequentially by a given Viterbi decoder stage—such as the channel symbols comprised of

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signal points  $X_0^\alpha$  and  $X_1^\alpha$ ,  $X_6^\alpha$  and  $X_7^\alpha$ —are now separated by none baud intervals.

Using more than three trellis encoder stages in the distributed trellis encoder and/or a signal point interleaver that separates signal points from the same channel symbol by more than three baud intervals would provide even greater separation and could, therefore, potentially provide even greater improvement in Viterbi decoding. However, such improvement comes at a price—that price being increased decoding delay—particularly as the number of trellis encoders is increased beyond three. An engineering trade-off can be made, as suits any particular application.

Moreover, it is desirable for the signal point interleaver to provide a sequence in which every  $N^{\text{th}}$  signal point in the interleaved signal point stream is the  $N^{\text{th}}$  signal point of a channel symbol. (The reason this is desirable is described in detail hereinbelow.) In the case of an  $N=2$ , four-dimensional signaling scheme, this means that every second, that is “every other,” signal point in the interleaved stream is the second signal point of the channel symbol from which it comes. In the case of an  $N=4$ , eight-dimensional signaling scheme, this means that every fourth signal point in the interleaved stream is the fourth signal point of the channel symbol from which it comes. Indeed, this criterion is in fact satisfied in the embodiment of FIG. 3. Note that each one of signal points  $X_0^\alpha$ ,  $X_2^\beta$ ,  $X_4^\gamma$ ,  $X_6^\alpha$ , . . . , which appear as every other signal point in the interleaved stream, is the second signal point of one of the four-dimensional channel symbols. Note that not all rearrangements of the signal points will, in fact, satisfy this criterion, such as, if the two signal points of a channel symbol are separated by two, rather than three, baud intervals.

Satisfying the above criterion is advantageous because it enhances the accuracy with which phase tracking loop 457 performs its function. This is so because the arrival of an  $N^{\text{th}}$  signal point of a given symbol means that all the signal points comprising that channel symbol have arrived. This, in turn, makes it possible to form a decision as to the identity of that channel symbol by using the minimum accumulated path metric in the Viterbi decoder stages. (Those decisions are fed back to the tracking loop by decoder stages 419 $\alpha$ , 419 $\beta$  419 $\gamma$  on leads 494, 495 and 496, respectively, via switching circuit 456.) Without having received all of the signal points of a channel symbol, one cannot take advantage of the accumulated path metric information but, rather, must rely on the so-called raw sliced values, which is less accurate. By having every  $N^{\text{th}}$  signal point in the interleaved stream be the  $N^{\text{th}}$  signal point of a channel symbol; we are guaranteed that the time between adjacent such path metric “decisions” supplied to the phase tracking loop is, advantageously, never more than  $N$  baud intervals.

The foregoing merely illustrates the principles of the invention. Thus although the illustrative embodiment utilizes a four-dimensional signaling scheme, the invention can be used with signaling schemes of any dimensionality. In the general,  $2N$ -dimensional, case each stage of the distributed trellis encoder would provide  $N$  two-dimensional subset identifiers to switching circuit 337 before the latter moves on to the next stage. And, of course, each stage of the distributed Viterbi decoder would receive  $N$  successive received signal points. The distributed trellis encoder and distributed Viterbi decoder can, however, continue to include three trellis



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encoders and still maintain, independent of the value of  $N$ , a separation of three baud intervals in the channel between signal points that are from channel symbols that are adjacent in the trellis encoder. If a greater separation of such signal points is desired, more stages can be added to the distributed trellis encoder/Viterbi decoder, just as was noted above for the four-dimensional case. However, when dealing with  $2N$ -dimensional signaling where  $N > 2$ , it is necessary to add additional delay elements to the signal point interleaver/deinterleaver in order to maintain a three-baud-interval separation among the signal points from any given channel symbol.

Consider, for example, the case of  $N=4$ , i.e., an eight-dimensional case. Looking again at FIG. 3, the three (8D) stages of the distributed trellis encoder would generate the three streams of subset identifiers  $\alpha_0 \alpha_1 \alpha_2 \alpha_3 \alpha_{12} \dots, \beta_4 \beta_5 \beta_6 \beta_7 \beta_{16} \dots$ , and  $\gamma_8 \gamma_9 \gamma_{10} \gamma_{11} \gamma_{20} \dots$ , respectively. This would lead to the following stream of signal points of eight-dimensional trellis encoded channel symbols at the output of the QAM encoder on lead 325:  $X_0^\alpha X_1^\alpha X_2^\alpha X_3^\alpha X_4^\beta X_5^\beta X_6^\beta X_7^\beta X_8^\gamma X_9^\gamma X_{10}^\gamma X_{11}^\gamma X_{12}^\alpha \dots$ . Signal point interleaving could be carried out by substituting signal point interleaver 641 of FIG. 6 for interleaver 341. Interleaver 641, in addition to direct connection 6414, includes one-, two-, and three-symbol delay elements 6413, 6412 and 6411, respectively.

The signal points on lead 325, after passing through interleaver 641, would appear on lead 342 in the following order:  $X_0^\alpha X_{-3}^\gamma X_{-6}^\beta X_{-9}^\alpha X_4^\beta X_1^\alpha X_{-2}^\gamma X_{-5}^\beta X_8^\gamma X_5^\beta X_2^\alpha X_{-1}^\gamma X_{12}^\alpha X_9^\gamma X_6^\beta X_3^\alpha X_{16}^\beta X_{13}^\alpha X_{10}^\gamma X_7^\beta \dots$  where signal points with negative subscripts are, of course, signal points that arrived before signal point  $X_0^\alpha$  and were already stored in the delay elements 6411, 6412 and 6413. Examination of this signal point stream will reveal that there is either a three- or five-baud separation between signal points of channel symbols that are processed sequentially by the same trellis encoder stage, e.g.,  $X_3^\alpha$  and  $X_{12}^\alpha$ ; that adjacent signal points of any one channel symbol, e.g.,  $X_0^\alpha$  and  $X_1^\alpha$ , are separated by five baud intervals; and that the four signal points comprising any particular one channel symbol are separated by fifteen baud intervals.

FIG. 7 shows the structure of a deinterleaver 741 that could be used in the receiver of FIG. 4 in place of deinterleaver 441 in order to restore the signal points of the eight-dimensional channel symbols to their original order. This structure, which is the inverse of interleaver 641, includes delay stages 7411, 7412 and 7413, as well as direct connection 7414.

It will be appreciated that, although various components of the modem transmitter and receiver are disclosed herein for pedagogic clarity as discrete functional elements and indeed—in the case of the various switching circuits—as mechanical elements, those skilled in the art will recognize that the function of any one or more of those elements could be implemented with any appropriate available technology, including one or more appropriately programmed processors, digital signal processing (DSP) chips, etc. For example, multiple trellis encoders and decoders can be realized using a single program routine which, through the mechanism of indirect addressing of multiple arrays within memory, serves to provide the function of each of the multiple devices.

It will thus be appreciated that those skilled in the art will be able to devise numerous arrangements which,

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although not explicitly shown or described herein, embody the principles of the invention and are within its spirit and scope.

We claim:

1. Apparatus for forming a stream of trellis encoded signal points in response to input information, said apparatus comprising

means for generating a plurality of streams of trellis encoded channel symbols in response to respective portions of said input information, each of said channel symbols being comprised of a plurality of signal points, and

means for interleaving the signal points of said generated channel symbols to form said stream of trellis encoded signal points, said interleaving being carried out in such a way that the signal points of each channel symbol are non-adjacent in said stream of trellis encoded signal points and such that the signal points of adjacent symbols in any one of said channel symbol streams are non-adjacent in said stream of trellis encoded signal points.

2. The apparatus of claim 1 wherein said means for generating generates three of said streams of trellis encoded channel symbols, and wherein said means for interleaving causes there to be interleaved between each of the signal points of each channel symbol at least two signal points from other channel symbols of said streams of trellis encoded channel symbols.

3. The apparatus of claim 1 wherein said channel symbols are  $2N$ -dimensional channel symbols,  $N > 1$ , and wherein said means for interleaving causes every  $N^{th}$  signal point in said interleaved signal point stream to be the  $N^{th}$  signal point of a respective one of said channel symbols.

4. The apparatus of claim 2 wherein said channel symbols are  $2N$ -dimensional channel symbols,  $N > 1$ , and wherein said means for interleaving causes every  $N^{th}$  signal point in said interleaved signal point stream to be the  $N^{th}$  signal point of a respective one of said channel symbols.

5. A modem comprising

means for receiving a stream of input bits, means for dividing said stream of input bits into a stream of uncoded bits and a plurality of streams of trellis bits,

means for independently trellis encoding each of said plurality of streams of trellis bits to generate respective streams of data words each identifying one of a plurality of predetermined subsets of the channel symbols of a predetermined  $2N$ -dimensional constellation,  $N$  being an integer greater than unity, each of said channel symbols being comprised of a plurality of signal points,

means for selecting an individual channel symbol from each identified subset in response to said stream of uncoded bits to form a stream of channel symbols, and

means for generating a stream of output signal points, said signal point stream being comprised of the signal points of the selected channel symbols, the signal points of said signal point stream being sequenced in such a way that signal points that are either a) part of the same channel symbol, or b) part of channel symbols that are adjacent to one another in said channel symbol stream, are separated in said output stream by at least one other signal point.

6. The apparatus of claim 5 wherein said trellis encoding means includes a plurality of trellis encoder stage

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means for trellis encoding respective ones of said streams of trellis bits.

7. The apparatus of claim 5 wherein said means for selecting includes means for modulus converting said stream of uncoded bits.

8. The apparatus of claim 5 wherein said channel symbols are 2N-dimensional channel symbols,  $N > 1$ , and wherein said means for generating causes every  $N^{\text{th}}$  signal point in said stream of output signal points to be the  $N^{\text{th}}$  signal point of a respective one of said channel symbols.

9. Receiver apparatus for recovering information from a received stream of trellis encoded signal points, said signal points having been transmitted to said receiver apparatus by transmitter apparatus which generates said signal points by generating a plurality of streams of trellis encoded channel symbols in response to respective portions of said information, each of said channel symbols being comprised of a plurality of signal points, and by interleaving the signal points of said generated channel symbols to form said stream of trellis encoded signal points, said interleaving being carried out in such a way that the signal points of each channel symbol are non-adjacent in said stream of trellis encoded signal points and such that the signal points of adjacent symbols in any one of said channel symbol streams are non-adjacent in said stream of trellis encoded signal points,

said receiver apparatus comprising  
means for deinterleaving the interleaved signal points to recover said plurality of streams of trellis encoded channel symbols, and  
a distributed Viterbi decoder for recovering said information from the deinterleaved signal points.

10. The apparatus of claim 9 further comprising  
a phase tracking loop, and  
means for adapting the operation of said phase tracking loop in response to minimum accumulated path metrics in said distributed Viterbi decoder.

11. A method for forming a stream of trellis encoded signal points in response to input information, said method comprising the steps of

generating a plurality of streams of trellis encoded channel symbols in response to respective portions of said input information, each of said channel symbols being comprised of a plurality of signal points, and

interleaving the signal points of said generated channel symbols to form said stream of trellis encoded signal points, said interleaving being carried out in such a way that the signal points of each channel symbol are non-adjacent in said stream of trellis encoded signal points and such that the signal points of adjacent symbols in any one of said channel symbol streams are non-adjacent in said stream of trellis encoded signal points.

12. The method of claim 11 wherein said generating step generates three of said streams of trellis encoded channel symbols, and wherein said interleaving step causes there to be interleaved between each of the signal points of each channel symbol at least two signal points from other channel symbols of said streams of trellis encoded channel symbols.

13. The method of claim 11 wherein said channel symbols are 2N-dimensional channel symbols,  $N > 1$ , and wherein said interleaving step causes every  $N^{\text{th}}$  signal point in said interleaved signal point stream to be

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the  $N^{\text{th}}$  signal point of a respective one of said channel symbols.

14. The method of claim 12 wherein said channel symbols are 2N-dimensional channel symbols,  $N > 1$ , and wherein said interleaving step causes every  $N^{\text{th}}$  signal point in said interleaved signal point stream to be the  $N^{\text{th}}$  signal point of a respective one of said channel symbols.

15. A method for use in a modem, said method comprising the steps of

receiving a stream of input bits,  
dividing said stream of input bits into a stream of uncoded bits and a plurality of streams of trellis bits,

independently trellis encoding each of said plurality of streams of trellis bits to generate respective streams of data words each identifying one of a plurality of predetermined subsets of the channel symbols of a predetermined 2N-dimensional constellation, N being an integer greater than unity, each of said channel symbols being comprised of a plurality of signal points,

selecting an individual channel symbol from each identified subset in response to said stream of uncoded bits to form a stream of channel symbols, and

generating a stream of output signal points, said signal point stream being comprised of the signal points of the selected channel symbols, the signal points of said signal point stream being sequenced in such a way that signal points that are either a) part of the same channel symbol, or b) part of channel symbols that are adjacent to one another in said channel symbol stream, are separated in said output stream by at least one other signal point.

16. The method of claim 15 wherein in said trellis encoding step a plurality of trellis encoder stages trellis encode respective ones of said streams of trellis bits.

17. The method of claim 15 wherein said selecting step includes the step of modulus converting said stream of uncoded bits.

18. The method of claim 15 wherein said channel symbols are 2N-dimensional channel symbols,  $N > 1$ , and wherein said generating step causes every  $N^{\text{th}}$  signal point in said stream of output signal points to be the  $N^{\text{th}}$  signal point of a respective one of said channel symbols.

19. A method for use in a receiver to recover information from a received stream of trellis encoded signal points, said signal points having been transmitted to said receiver apparatus by a method which includes the steps of

generating a plurality of streams of trellis encoded channel symbols in response to respective portions of said information, each of said channel symbols being comprised of a plurality of signal points, and interleaving the signal points of said generated channel symbols to form said stream of trellis encoded signal points, said interleaving being carried out in such a way that the signal points of each channel symbol are non-adjacent in said stream of trellis encoded signal points and such that the signal points of adjacent symbols in any one of said channel symbol streams are non-adjacent in said stream of trellis encoded signal points,

said method comprising the steps of  
deinterleaving the interleaved signal points to recover said plurality of streams of trellis encoded channel symbols, and

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using a distributed Viterbi decoder to recover said information from the deinterleaved signal points.

20. The method of claim 19 wherein said receiver includes a phase tracking loop and wherein said method comprises the further step of adapting the operation of said phase tracking loop in response to minimum accumulated path metrics in said distributed Viterbi decoder.

21. Data communication apparatus comprising means for receiving input information,

means for generating a plurality of streams of trellis encoded channel symbols in response to respective portions of said input information, each of said channel symbols being comprised of a plurality of signal points,

means for interleaving the signal points of said generated channel symbols to form a stream of trellis encoded signal points, said interleaving being carried out in such a way that the signal points of each channel symbol are non-adjacent in said stream of trellis encoded signal points and such that the signal points of adjacent symbols in any one of said channel symbol streams are non-adjacent in said stream of trellis encoded signal points,

means for applying the stream of trellis encoded signal points to a transmission channel,

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means for receiving the stream of trellis encoded signal points from the channel,

means for deinterleaving the interleaved signal points to recover said plurality of streams of trellis encoded channel symbols, and

a distributed Viterbi decoder for recovering said information from the deinterleaved signal points.

22. The apparatus of claim 21 wherein said means for generating generates three of said streams of trellis encoded channel symbols, and wherein said means for interleaving causes there to be interleaved between each of the signal points of each channel symbol at least two signal points from other channel symbols of said streams of trellis encoded channel symbols.

23. The apparatus of claim 21 wherein said channel symbols are  $2N$ -dimensional channel symbols,  $N > 1$ , and wherein said means for interleaving causes every  $N^{\text{th}}$  signal point in said interleaved signal point stream to be the  $N^{\text{th}}$  signal point of a respective one of said channel symbols.

24. The apparatus of claim 22 wherein said channel symbols are  $2N$ -dimensional channel symbols,  $N > 1$ , and wherein said means for interleaving causes every  $N^{\text{th}}$  signal point in said interleaved signal point stream to be the  $N^{\text{th}}$  signal point of a respective one of said channel symbols.

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